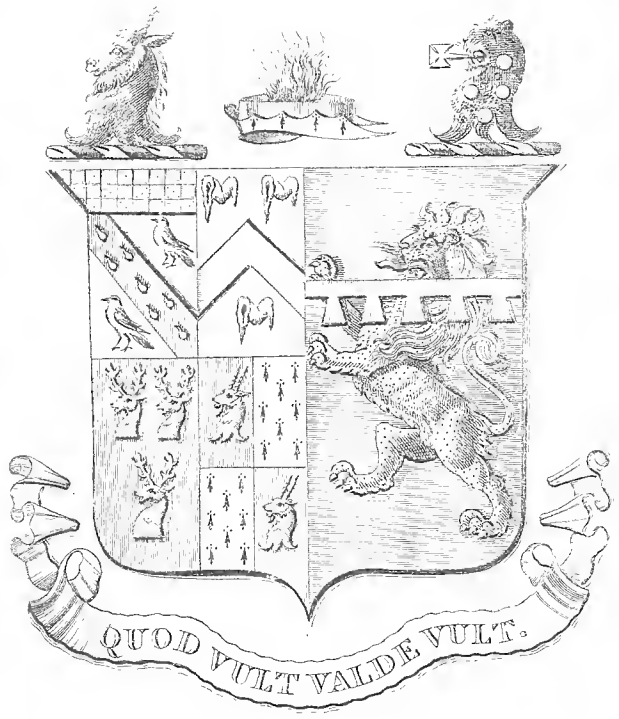

J. C. Mansel-Pleydell.

SCIENTIFIC RESULTS

OF

THE SECOND YARKAND MISSION;

BASED UPON THE COLLECTIONS AND NOTES

OF THE LATE

FERDINAND STOLICZKA, PH.D.

GEOLOGY.

BY

W. T. BLANFORD, F.R.S.

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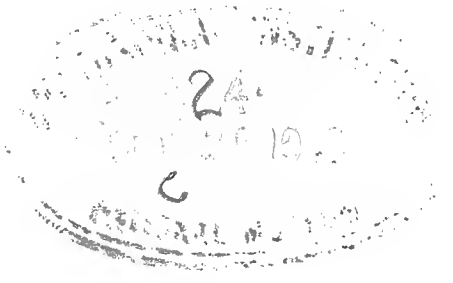


SCIENTIFIC RESULTS

OF

THE SECOND YARKAND MISSION.

GEOLOGY.

By W. T. BLANFORD.

Introduction and General Sketch of the Geology of Western Tibet.

IT is, of course, very difficult to do justice to a rough travelling diary, such as Dr. Stoliczka's. In such a diary first impressions are very often recorded, and subsequent observations do not always show how far the first notes require modification. To the writer this is a simple matter—his notes are memoranda serving to recall details to his mind; but to another, who does not possess the clue, it is very often difficult to ascertain how far the notes in the diary agree with the final conclusions of the diarist.

Of the greater portion of Dr. Stoliczka's journey the geological results have already been published by himself in the Records of the Geological Survey of India[1] and the Quarterly Journal of the Geological Society.[2] A comparison of these papers with the original notes shows that everything of interest in the latter, with the exception of an occasional section, has been extracted and condensed. These papers will, therefore, be here republished in sequence, with the addition only of such sections as can be extracted from the diary. The papers already mentioned contain the record of the geological observations from Leh, in Ladák, to Káshghar, and during two excursions from Káshghar to the northward. The notes from the Panjáb, at Mari, through Kashmir, to Leh, refer to ground which had been previously examined either by Dr. Stoliczka himself, or by other geologists; but as very little geological information has yet been published concerning Kashmir, the notes are here repeated. Of the journey from Káshghar to the Pámir nothing has hitherto appeared in print.

A brief summary of Dr. Stoliczka's previous geological observations in the North-Western Himalayas will aid the reader in understanding the notes made in his last journey. His earlier travels enabled him to classify the rocks seen in the mountain ranges of Spiti, Kulu, Lahaul, Rupshú, Záskar or Zánskar, Ladák, and the neighbouring districts south of the Indus

[1] Vol. VII, 1874, pp. 12, 49, 51, 81; and Vol. VIII, 1875, p. 13.
[2] Vol. XXX, 1874, pp. 568, 571, 574.

valley, and to show that several formations, some of which had not previously been detected, are represented in this portion of the Himalayas. In his last journey he has ascertained the extension of some of the same rocks to the northward; and as the regions lying east and west of his route are almost unknown, and those to the northward but imperfectly explored, almost the whole geological interest of his journey, with the exception of his observations on a part of the Thian Shan range north of Káshghar, depends upon the connection of the formations found by him in the Kashmir territories north of the Indus, and in the ranges known on our maps as the Mastágh (Karakoram), Kuenluen, and Bolor, with those previously explored in the country south of the Indus between Simla, Spiti, and Kashmir.

Dr. Stoliczka spent the summers of 1864 and 1865 in the North-Western Himalayas and Western Tibet, exploring the geology of the ranges. On his first journey, when he was accompanied by Mr. Mallet, he went north-east from Simla, crossing the Sutlej at the Wangtu bridge, and traversing Bissahir: he crossed the Bhabeh pass, and examined the Spiti valley, already known to be rich in fossil remains from the researches and collections of Gerard, Strachey, and others. From Spiti he marched nearly due north to the Indus, near Sangdo, by the Parang pass and the Tso-morari.[1] After two days' march up the Indus, he returned to the Spiti valley by a more eastern route, traversing Hanle, and crossing the Tagling pass. After spending some days in the examination of the important formations of Spiti, he marched back to Simla, through Lahaul and Kulu, at some distance to the west of his journey northwards.

The journey in 1865 occupied six months, from the beginning of May to the end of October. The area examined lay for the most part to the north-west of his former route, and extended to Leh, Kargil (north of Drás), and Srinagar. Starting from Simla, as before, he marched north by west, through Suket and Mandi, to Kulu, and thence, across the Rotang pass, to Kyelang in Lahaul. Thence he turned east by north, and crossed the Baralatse pass to the Tsaráp valley, and proceeded across several other passes to Korzog, in Rupshú, on the Tso-morari. Here he turned north-west, and travelled by the Taglang pass to the Indus, and to Leh. From Leh he went almost south-west, across the mountains, to Padam; thence north-west again to Suroo and Kargil, from which place he visited the Indus valley to the northward. This was his furthest point to the north-west in any of his journeys. From the Indus, north of Kargil, he marched south-west by Drás into the Kashmir valley, and, after a few days spent at Srinagar, he returned by the direct route, *viâ* Islamabad, Kishtwar, Budrawar, Chamba, and Kángra, to Simla. He suffered greatly from exposure to cold during part of this journey, especially in the mountains of Záskar, south of Leh; and although he gradually recovered from the effects of his Himalayan travels, it is probable that permanent injury to his constitution—not very strong originally—was produced by them.

The results of his explorations, and especially of his first journey, were very great. It has been already mentioned that the occurrence of fossils in the Spiti valley, and in some other parts of the trans-Himalayan region, had long been known; and considerable collections had been made by Gerard, Strachey, the brothers Schlagintweit, and others,—one having been obtained by Messrs. Theobald and Mallet, of the Geological Survey. The fossils collected had, moreover, been to a great extent described. Dr. Gerard's collection was, partly and imperfectly, illustrated by the Rev. R. Everest in the Asiatic Researches, Vol. XVIII, p. 107, plates I & II, and fully described by Mr. H. F. Blanford in 1863.[2] A large collection

[1] Tso = lake.

[2] Journal of the Asiatic Society, Bengal, Vol. XXXII, p. 124.

formed by Colonel Strachey, chiefly at Niti, was described by Messrs. Salter and Blanford in 1865;[1] whilst the Schlagintweits' collections were entrusted to Professor Oppel, and descriptions and figures of them published by him.[2] Other less important notes had appeared, and several imperfect descriptions of the geology; but no thorough sections had been made, and, beyond the general fact that fossils of silurian, carboniferous, triassic, liassic, and jurassic forms were represented in the various collections, very little, indeed, had been done towards elucidating the geological structure of the country.

This work was admirably carried out by Dr. Stoliczka. In the course of a single season's work, in a most difficult country, amongst some of the highest mountains in the world, he clearly established the sequence of formations; and, from his extensive palæontological knowledge, was able to do this with an accuracy, which has stood the test of subsequent research. He, moreover, added to the list of known formations the representatives of rhætic and cretaceous rocks not previously detected, and showed that some of the other groups might be sub-divided.

The presence of this remarkable series of marine fossiliferous beds in the North-Western Himalayan region—a series in which all the principal European palæozoic and mesozoic groups, except the cambrian, devonian, permian, and neocomian, are represented—is none the less surprising, that scarcely any of the formations, except a few oolitic and cretaceous strata, are found in the peninsula of India, beyond the Indus river basin. In the hills of the Panjáb some of the formations have been detected, but they were until recently very imperfectly known.

The following is the sequence of formations, with the fossils found in them by Dr. Stoliczka:—

I.	SUB-RECENT OR NEWER TERTIARY.		River and lacustrine deposits.—Karewah deposits of Godwin-Austen, &c.; *Mammalian bones.*
II.	TERTIARY	... EOCENE	... (Nummulitic) Indus or Shingo beds.—*Nummulites ramondi; N. exponens.*
III.	MESOZOIC	... CRETACEOUS	(9) Chikkim shales.
			(8) Chikkim limestone.—*Rudistes* (fragments), *Nodosaria*, 2 sp., *Dentalina* (*annulata?*), *Rotalia*, sp., *Textilaria*, 2 sp., *Haplophragmium*, sp., *Cristellaria*, sp.
	.....	UPPER JURASSIC	(7) Gieumal sandstone.—*Ostrea*, sp., near *O. gregaria;* another species near *O. sowerbii; Gyphæa*, sp., *Avicula echinata, Mytilus mytiloideus, Lima*, sp., *Amusium demissum, Pecten bifrons, Anatina spitiensis*, Stol., *A.* sp., nov., *Opis*, sp.
	.....	MIDDLE JURASSIC	(6) Spiti shales.—*Salenia?* sp., *Terebratula* sp., *Rhynconella varians, Ostrea*, sp., *Pecten lens, Amusium* (conf. *Pecten stolidus*), *Aucella blanfordiana*, Stol., *A. leguminosa*, Stol., *Lima*, sp., near *L. rigida, Inoceramus hookeri, Macrodon egertonianum*, Stol., *Nucula*, sp., *Nucula cuneiformis, Cyprina trigonalis, Trigonia costata, Astarte unilateralis, A. major, A. spitiensis*, Stol., *A. hiemalis*, Stol., *Homomya tibetica, Pleurotomaria*, 2 sp., *Ammonites acucinctus, A. strigilis, A. macrocephalus,*[3] *A. octagonus, A. hyphasis, A. parkinsoni, A. theodorii, A. sabineanus, A. spitiensis, A. curvicosta, A. braikenridgii, A. nivalis*, Stol., *A. liparus, A. triplicatus, A. biplex, A. alatus, Anisoceras gerardianum, Belemnites canaliculatus, B. clavatus.*
	.....	.....	(5) Clayey slates.—*Belemnites*, sp., *Posidonomya ornata.*

[1] Palæontology of Niti, printed for private circulation, Calcutta.

[2] Palæontologische Mittheilungen, 1863, p. 267; 1865, p. 289.

[3] According to Dr. Waagen, Palæontologia Indica, Ser. IX, 3, p. 237, foot-note, this and several other species are not identical with the European fossil forms to which they were referred by Dr. Stoliczka.

III. MESOZOIC		MIDDLE LIASSIC	(4) Upper Tagling limestone.—*Terebratula sinemuriensis, Modiola,* sp. (resembling *Mytilus subreniformis*), *Neritopsis* (conf. *N. elegantissima*), *Chemnitzia undulata, Trochus latilabrus, Trochus epulus, T. attenuatus, Eucyclus* (*Amberleya*), sp., *Acteonina* (conf. *A. cincta*), *Nerinea* (conf. *N. goodhalii*), *Belemnites,* sp., *Ammonites* (conf. *macrocephalus*).
.....		LOWER LIASSIC	(3) Lower Tagling limestone.—*Terebratula gregaria, T. pyriformis, T. punctata, T.* (*Waldheimia*) *schafhæutli, Rhynconella obtusifrons, R. pedata, R. fissicostata, R. austriaca, R. variabilis, R. ringens, Ostrea* (conf. *O. acuminata*), *O.* (conf. *O. anomala*), *Amusium,* sp. *Pecten* (conf. *P. palosus*), *P. moniliger, P. sabal, P. bifrons, P. valoniensis, Lima densicostata, Avicula inæquivalvis, A. punctata, Gervillia,* sp. (near G. *olifex*), *Arca* (*Macrodon*), sp. (apparently *A. lycetti*), *Dentalium,* sp. (near *D. giganteum*), *Nerita,* sp. nov., *Natica* (conf. *N. pelops*), *Chemnitzia* (conf. *C. coarctata*), *C.,* sp. (near C. *phidias*), *Nerinea,* sp. (near *N. goodhalii*), *Ammonites* (conf. *A. germanii*), *A.,* sp. (conf. *A. macrocephalus*), *Belemnites budhaicus,* Stol., *B. bisulcutus,* Stol., *B. tibeticus,* Stol.
.....		RHÆTIC	(2) Para limestone.—*Dicerocardium himalayense,* Stol., *Megalodon triqueter.*
.....		TRIASSIC	(1) Lilang series.—*Encrinus cassianus, Spirifer,* sp. n., *S.* (*Spiriferina*), (conf. *S. fragilis*), *S.* (*Spiriferina*) *stracheyi, S.* (*Spiriferina*) *lilangensis,* Stol., *S. spitiensis,* Stol., *Rhynconella mutabilis,* Stol., *R. theobaldiana,* Stol., *R. salteriana,* Stol., *R. retrocita* var. *augusta,* Stol., *Athyris strohmeyeri, A. deslongchampsi, Waldheimia stoppanii, Halobia lommeli, Monotis salinaria,*[1] *Lima* (conf. *L. ramsaueri*), *L.,* sp. nov., *Myoconcha lombardica, Discohelix,* sp., *Pleurotomaria* (conf. *P. buchi*), *P. sterilis,* Stol., *Orthoceras,* sp., *O. salinarium, O. latiseptum, O. dubium, Nautilus spitiensis,* Stol., *Clydonites oldhamianus,* Stol., *C. hauerinus,* Stol., *Ammonites floridus, A. jollyanus, A. khanikofi, A. gaytani, A. difissus, A. ausseanus, A. gerardi, A. medleyanus,* Stol., *A. studeri, A. thuillieri, A. malletianus,* Stol., *A. batteni,* Stol.
IV. PALÆOZOIC	...	CARBONIFEROUS	... Kuling series.—*Spirifer moosakhailensis, S. keilhavii, S. tibeticus,* Stol., *S. altivagus,* Stol., *Productus purdoni, P. semireticulatus, P. longispinus, Avicula,* sp., *Cardiomorpha,* sp., *Aviculopecten,* sp., *Orthoceras,* sp.
		SILURIAN ?	... Muth series.—*Syringopora,* sp., *Cyathophyllum,* 2 sp., Crinoid stems, *Orthis* sp. (near *O. thakil,* var. *striato-costata* and var. *convexa*), *O.* (near *O. compta*), *O.* (near *O. tibetica*), *O.* (conf. *O. resupinata*), *Strophomena,* sp., *Tentaculites,* sp.
		SILURIAN	... Bhabeh series.—*Orthis,* sp. ? *Chætetes yak.*
V.	...	METAMORPHIC	... Central gneiss.

But, although the general sequence of the beds was established, the observations made were insufficient to enable a map to be prepared showing the distribution of the different strata. Further examination was necessary for this purpose; and Dr. Stoliczka always hoped to return to the Himalayas and complete the work he had so well begun. The severe and long-continued labour necessary for the preparation of his great work on the cretaceous fossils of Southern India engrossed the whole of his time; and, as has already been mentioned, his health was seriously affected by the exposure he underwent in his second Himalayan journey, so that, for a year or two at least, he was unfitted for work involving severe exertion. Thus the sketch he made—for such it was—has never been filled up; no geological map of the Western Himalayas has ever been published, and the idea which can be formed of the distribution of the known strata is, at the best, fragmentary.

It is as well, before proceeding further, to point out, in such a manner as to render it easily recognised on the map, the area to which Dr. Stoliczka's observations were chiefly con-

[1] Mem., Geol. Surv. Ind., V, pp. 345, 352.

fined. This area has somewhat the form of an oblong, with the longer axis north-west and south-east. Its north-eastern boundary is formed by the Indus, whilst the south-western boundary is far less regular, and, bulging out near the southern corner, includes a considerable tract of country about Spiti, Kulu, and Lahaul. The south-eastern limit of the area examined is formed by a line drawn north-north-east from Simla to the Indus, the north-western extremity being near Kargil and Drás. The south-western boundary is formed first by the range which separates the Kashmir valley from that of the Indus, and the continuation of the same in the Záskar range as far as the Baralatse or Baralacha pass, whence the boundary turns southward and embraces the country between the Baralatse range and the snowy ridges north of the Sutlej valley, near Simla.[1]

The general formation of the mountains near Simla is too irregular for any definite range of great length to be distinguished. The ridges throughout the North-Western Himalayas and Western Tibet have a general north-west and south-east direction, shown by the main course of both the mountains and river valleys; and this direction is, of course, due in a great measure to the strike of the various rocks, and the outcrop of softer or harder strata. Commencing at the south,[2] the range north of the Sutlej, opposite Simla, usually considered the true Himalaya, and well known to all visitors to Simla as the snowy range, is chiefly composed of the rock called by Dr. Stoliczka "central gneiss."[3] The mineralogical character by which this rock is distinguished is the presence of albite in large quantities, with quartz, orthoclase, and biotite, and a still more marked peculiarity in the constant occurrence of veins of albite granite, which traverse the mass in every direction.

To the south of the central gneiss various metamorphic rocks are found: to the north or north-east of it commences the sedimentary area of Tibet. It is palpable that this central gneiss is not only pre-silurian in age, but that it must, in all probability, have been metamorphosed before the deposition of the silurian strata. Hence its importance: for whilst other metamorphic formations of the Himalayas and Tibet are, probably, represented by fossiliferous sedimentary deposits in other parts of the range, the central gneiss appears to belong to an older period altogether.

To the north-west this gneissic formation extends but a short distance. The natural continuation of the range formed by it would be the Pir Panjál, south-west of Kashmir; but this consists of newer formations. Dr. Stoliczka was inclined to consider the Záskar ridge as the probable continuation of the central axis, as he considered it, and to look upon the gneiss of which that range consists as the representative of the central gneiss. It, however, wants the albite granite.

The highest peaks of the snowy Himalayan range consist of silurian rocks dipping northward, and followed in ascending order by carboniferous, triassic, and jurassic strata.

[1] For convenience sake, it may be as well to point out that the principal ranges of the North-Western Himalaya and Western Tibet, all running nearly north-west and south-east, are, commencing on the north, the Kuenluen range on the edge of the Yárkand plain; the Mastágh range traversed by the Karakoram pass, and forming the main ridge, separating the Indus watershed from that of the Yárkand plain; the Ladák range running along the northern (or north-eastern) bank of the Indus, and separating its valley from that of the Shayok; the Záskar range, which forms the south-western limit of the Indus drainage, extending along the north-eastern boundary of Kashmir, and the continuation of which to the south-west is sometimes known as the Baralatse range, and the Himalaya proper, the north-western continuation of which is the Pir Panjál.

[2] The account which follows is derived in great part from Mr. H. B. Medlicott's sketch of the Geology of the Panjáb and its dependencies in the Panjáb Gazetteer.

[3] Some important additional information concerning this rock has recently been furnished by Colonel C. A. McMahon, who has determined by microscopical examination that this gneiss possesses the characters of an igneous rock, in parts at all events, and that it must probably have been in a more or less plastic or fluid state.—Records, Geol. Surv. Ind., X, p. 222.

The cretaceous rocks have only been found at a few localities in Spiti and Rupshú; but the jurassic and liassic strata upon which they rest occupy a large area, constantly spoken of by Dr. Stoliczka as the jurassic ellipse, and having an elliptical form, with the long axis in the normal north-west, south-east direction. These beds were traced from Spiti and Southern Rupshú to Záskar, where they end out against the great granite and syenitic mass of Little Tibet. To the south-west the same jurassic rocks are known to exist in Northern Kumaon. Except close to the Karakoram pass, where liassic beds occur, and a little farther east by south in the Lokzhung range, capped by cretaceous rocks,[1] none of these middle and upper mesozoic rocks have hitherto been found in Western Tibet beyond the limit of this basin; nor have they hitherto been found in Kashmir proper, although some of them recur in the hills near Mari (Murree).

The silurian, carboniferous, and triassic (including the rhætic[2]) formation have a far wider range, and it is probable that their altered representatives form no inconsiderable proportion of the metamorphic rocks, which occupy so large an area in the Indus valley and its neighbourhood.

The silurian rocks on the south of the jurassic area have been traced at intervals from the Bhabeh pass, through Northern Lahaul and Záskar, to the neighbourhood of Drás, and they are probably, in Dr. Stoliczka's opinion, represented by some of the lower beds seen in the Indus valley below Leh, and in the Marka valley to the south. North-west of the jurassic area they have not been detected, and they may be represented by some of the metamorphic rocks.

The carboniferous series is distinctly developed both to the south-west and north-east of the jurassic area in the Spiti country, and it becomes even more prominent to the north-west. It occupies large areas in the Indus valley south-west and west of Leh, and reappears in the Kashmir valley. The triassic rocks appear everywhere to overlie the carboniferous, and to have nearly an equal extension.

Northern and Eastern Rupshú, to the north-east of the Spiti area, consists mainly of gneiss and other metamorphic rocks. The same crystalline formations form the whole of the range north of the Indus, from the sharp bend made by the river to the southward, north of Hanle, to Leh.

In the Indus valley itself, apart from all the secondary series of the Spiti basin, sandstones, shales, and clays are found, which have been proved to be of eocene age by the discovery in them of nummulites and other fossils. Where these were first observed by Dr. Stoliczka in Northern Rupshú, they were unfossiliferous, and their old and altered appearance made him suspect that they might be palæozoic. But near Leh they are much newer in appearance, and contain fossils which prove their age. Similar beds are seen west of Leh, as far as Kargil.

Lastly, eruptive rocks, containing serpentine, diallage, and epidote, occupy a considerable area around Hanle, east of Rupshú, and extend for many miles to the north-west, towards the Indus. Syenite is largely developed near Leh, and extends westward, towards Drás, occupying a considerable area about Kargil. Serpentine is associated with it.

If we look upon the snowy range north of Simla and the Záskar range as identical, and as forming the axis of the Himalayas, we may consider the palæozoic and mesozoic rocks of the Indus and Spiti valleys as lying between two great metamorphic ranges—that just mentioned and the Ladák range north of the Indus. To the north of Kashmir, however, the

[1] See note, p. 47.

[2] This formation was kept distinct by Dr. Stoliczka in his first paper, but subsequently he was disposed to unite it with the triassic group.

carboniferous and triassic beds completely lap round and replace the older metamorphics. In his last journey Dr. Stoliczka has shown that another great sedimentary region in the Karakoram area lies between the crystalline Ladák ridge and the gneissic rocks forming the Kuenluen. But in this region no oolitic or cretaceous beds have hitherto been found, the highest fossiliferous rocks observed being liassic.[1] North of the Kuenluen, however, the presence of a cretaceous formation was detected.

As occasional reference must be made in the ensuing pages to the names given by Mr. Medlicott to particular formations on the southern slopes of the Himalayas, a list of these groups, with their supposed trans-Himalayan equivalents, is appended. It must be remembered that the identifications are little more than surmises,[2] and were only suggested as probable by Dr. Stoliczka, no fossils having been found in the cis-Himalayan rocks below the nummulitics.

Age.	Cis-Himalayan.	Trans-Himalayan.
Pliocene and Miocene	Siwalik Náhan	Mammaliferous. Deposits of Tibet (? Karewah, in part).
Eocene (*Nummulitic*)	Sirmúr: Kasauli (purple and grey sandstones); Dagshai (red clays, purple and grey sandstones); Sabáthu (brown and grey clays and limestones).	Indus or Shingo beds.
Trias	Krol (limestone)	Lalang series.
Carboniferous	Infra-Krol (sandstone and carbonaceous shales)	Kuling series.
Silurian	Blini (limestone and conglomerate) Infra-Blini (slates and sandstone)	Muth. Bhabeh.

On the other hand, there is some slight possibility of the Krol limestone being nummulitic, and Mr. Medlicott at one time, and before the trans-Himalayan rocks had been classified by Dr. Stoliczka, was rather inclined to this view,[3] but he never considered the evidence in its favour of much importance.

In the following pages the order preserved is that of the journey: first, the notes taken from the diary of the route from the Panjáb to Leh, then the (previously printed) geological descriptions of the journey from Leh to Sháh-i-dula, and from Sháh-i-dula to Káshghar; next, the excursions from Káshghar to the Chadyr-kul and to Altyn Artysh; and finally, the notes from the diary of the journey to the Pámir, and of the return march from Yárkand to the Karakoram pass. The sections illustrative of the geology of the country are from sketches in Dr. Stoliczka's note-book; they are introduced, as they serve greatly to explain the relations of the rocks, but it should be remembered that the original drawings are frequently rough, and they may not, in some instances, have been quite correctly interpreted. Should subsequent research show the sections to require modification, the circumstances under which they were prepared should be remembered.

Dr. Stoliczka himself spoke of his geological results as meagre. This is, probably, the first impression of most travellers: either they have traversed enormous areas composed of

[1] Some obscure unfossiliferous sandstones near Kium, in Changchenmo, and at Aktágh, north of the Karakoram pass, were referred with doubt to the tertiary epoch.

[2] Mr. Lydekker's surveys, made since the above was written, have indicated that some modification is probably necessary in the above list of correlated strata. It appears now more probable that the Krol limestone is carboniferous.—Records, Geol. Survey of India, XI, p. 63

[3] Memoirs, Geological Survey, Vol. III, p. 170.

one or two rock groups, and the geology appears to them monotonous in the extreme, or they have been compelled to leave behind sections only half examined, in which the various formations succeed each other too rapidly for their sequence to be determined in a hurried journey. But in all cases, as with all discoveries in science, the observations require record and comparison for their value to appear. However useless they may seem at the time, no one can tell when the information may prove of the last importance.

For details as to the route, the map and diary should be consulted. All the explanatory notes in brackets and foot-notes in the subsequent pages are by myself, with the exception of the foot-notes marked (S) on page 18 and 20.

NOTE.—Since the above was in type, Dr. Waagen has kindly sent to me a paper, which he has just published in the Denkschrift Kais. Acad. Wiss. Wien. (Math. Naturwiss. Classe) for 1878, entitled "Ueber die Geographische Vertheilung der fossilen Organismen in Indien." In this paper he points out that, although the classification of the Spiti shales is still imperfect, and further subdivision may be necessary, it is clear that the great mass of these strata must be classed as Upper Jurassic (Kimmeridge and Tithonian), several of the Cephalopoda having been at first wrongly identified with European forms, and being of later age than was supposed. Dr. Waagen also notices that further to the westward in the Alpine Panjáb, near Mari (Murree), the Gieumal sandstone or its equivalent contains the *Trigoniæ* (*T. ventricosa, &c.*) characteristic of the Umia (Portlandian) group in Cutch.

According to Dr. Waagen, also, only the upper Tagling limestone, the representative of the 'Hierlatz beds' of the Alps, should be classed as Lias, the lower Tagling limestone, the equivalent of the Alpine 'Kössen beds,' being of Rhætic age. The Para limestone should be classed as upper triassic, and the Lilang series in part as middle triassic (Muschelkalk). Most of these relations had been pointed out by Dr. Stoliczka himself.

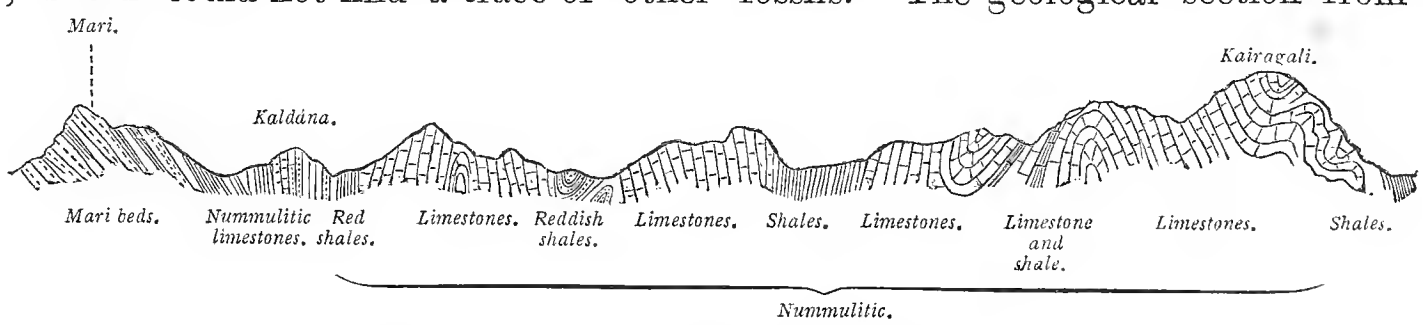
PART I.

Notes on the Geology from Mari (Murree) in the Punjab to Leh in Ladák.

[The following notes, it should be remembered, commence in the Panjáb, at Mari (Murree), the sanatarium lying a short distance north of Rawal Pindi. A "rough section showing the relation of the rocks near Mari," by Dr. Waagen, was published in the Records of the Geological Survey of India.[1] He showed that Mari is built on red slates and sandstones, newer than the nummulitics, but unfossiliferous, and that these beds are succeeded (the formations are too much crushed and contorted for anything like order in descent to be made out) by nummulitic limestone, jurassic and triassic beds; the jurassic beds being identified with the "Spiti shales." Dr. Waagen gave a section round Chamba Peak, from Kairagali to Changligali. Dr. Stoliczka describes that seen on the road round the other side of the mountain.

An account of the geology of the neighbourhood of Mari hill station in the Panjáb has also been given by Mr. A. B. Wynne,[2] of the Geological Survey of India, accompanied by a map and section. In this paper many additional details of the geology are given, and the same section is described which is here extracted from Dr. Stoliczka's note-book. Dr. Stoliczka's notes were made before Mr. Wynne's paper was published, although the latter had been written long before. Within the last two years the systematic geological survey of Kashmir has at length been commenced, and a large amount of information as to the distribution and relations of the different beds has been added by Mr. Lydekker.[3] In a few cases, as at the Zoji-la, slight changes have been shown to be necessary in the views formed by Dr. Stoliczka on his hurried journeys, but as a general rule his opinions have proved correct.]

July 3rd to 6th.—The Mari hill consists of sandstone and shales, the former full of *fucoids*, but I could not find a trace of other fossils.[4] The geological section from Mari



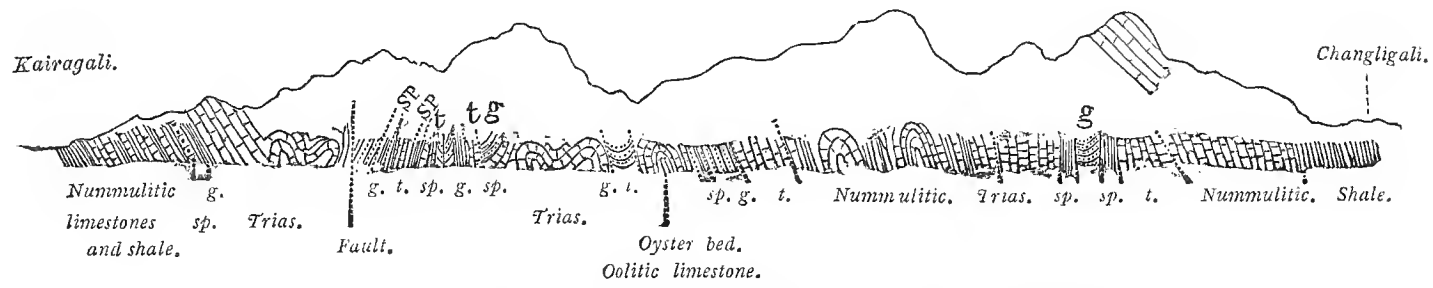
Section from Mari to Kairagali, distance 8 miles.

to Kairagali is rather simple, but thence along the road to Changligali it is rather complicated, and on the whole similar to that made by Waagen on the corresponding road passing

[1] Vol. V, 1872, p. 15.
[2] Records, Geological Survey of India, Vol. VII, p. 64.
[3] Rec. G. S. I., IX, p. 155; XI, p. 30.
[4] The Murree Beds of Mr. Wynne, see Quarterly Journal, Geological Society, 1874, p. 71, &c., and Rec. G. S. I., Vol. VII, p. 66.

round the other side of Chamba Peak.[1] The section from Changligali to Dangagali is a little more simple.

On the saddle at Kaldána the Mari beds dip towards the nummulitic shales, but at Sunnybank they are turned up sharply against the latter. There must have been a tremendous slip along this boundary. After some shales and crumbling sandstones, the southern side of the Kaldána hill consists chiefly of limestone, and then follow reddish shales and sandstones, very like those of the Mari group in general character. The shales are seen on the next saddle, succeeded chiefly by limestone and grey shale and carbonaceous sandstone, often very impure. These beds, the calcareous especially, are often full of nummulites, with an occasional pelecypod or gastropod.

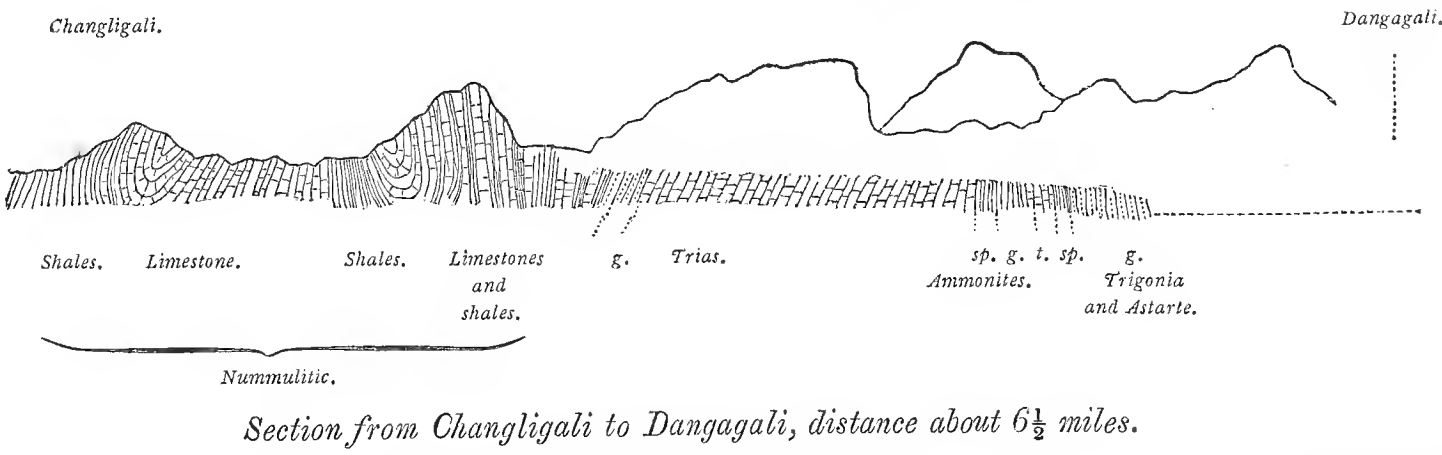


g. Gieumal sandstone (upper jurassic), typical, and occasionally very silicious.
sp. Spiti shales (jurassic), typical, but without concretions.
t. Trias.

Section from Kairagali to Changligali, distance a little above 2 miles.

The section on the western side of the Chamba Peak is even more contorted than that made by Waagen on the other (eastern) side. The general dip of the rock is towards the north-west, and the consequence is, that the rocks are dreadfully twisted in every stream: on the whole, the section is much more contorted than in the sketch.

The triassic limestone in contact with the Spiti shales is semi-oolitic, just like the Krol limestone in some places. Its thickness is generally from 10 to 30 feet, and then follows more compact grey limestone, sometimes full of small oysters. About half a mile from Kairagali, I got a good *Rhychonella* in it. Changligali lies on shales, but the next



Section from Changligali to Dangagali, distance about 6½ miles.

hill is limestone, mostly vertical, and dreadfully old-looking. If I had not occasionally got a nummulite out of the intermediate calcareous shales, I should certainly have taken the limestone for triassic. But, as a rule, the nummulitic limestone is highly bituminous, while the compact triassic limestone is apparently never bituminous, and the semi-oolitic (triassic) limestone is occasionally slightly bituminous, but generally not. Nummulitic beds continue about half-way to Dangagali. There is a great thickness of triassic limestone, and then

[1] Rec. G. S. I., Vol. V, 1872, p. 16.

at the last corner, before the road turns towards Dangagali, there is a repeated alternation of Gieumal, Spiti, and triassic beds. In the sandy beds of the Spiti shales I found a fragment of an Ammonite; and in the Gieumal sandstone, which occupies the whole corner, I got an *Astarte*, which is apparently the same as that I got at Lunari in the lower Umia beds,[1] and a *Trigonia*, but this is difficult to make out. The saddle on which Dangagali lies is again nummulitic shales.

[The most interesting point in the preceding sections is the identification of the Gieumal sandstone (upper jurassic). Dr. Waagen had previously recognised the Spiti shales, and had suggested that the sandstone represented the upper jurassic beds of Spiti[2]—a suggestion which Dr. Stoliczka confirmed. The red Mari beds are called Náhan (newer tertiary) by Dr. Stoliczka in his notes; but Mr. H. B. Medlicott, who is by far the best authority on the subject, considers that this is due to a mistake in the identification of the Náhan beds themselves near Simla, as proved by some notes in Dr. Stoliczka's diary, and that the rocks with which Dr. Stoliczka really identified the Mari beds belong to Mr. Medlicott's Dagshai division (older tertiary). Under these circumstances, I have ventured in the notes to substitute Mr. Wynne's name "Mari beds" for "Náhan," leaving the question of identification undecided.]

July 15th, Mari to Kohála.—Mari sandstone and shale are seen all the way dipping in various directions: near the Jhelum the dip is about north or north by east. The older rocks are seen on the left bank of the river, at the base of the Dangagali hill. The boundary between nummulitic and Mari beds runs along the stream coming from Kaldána: on the right bank are Mari sandstones and shales, dipping at about 40° or 50° towards north-east or east.

16th, Chatarkelas.—All the way I saw nothing but the same Mari sandstone and shale, mostly dipping to north-east or north-east by east.

17th to 23rd, Chatarkelas to Uri.—The Mari beds prevailed throughout the whole distance, and no others were seen on the left bank of the Jhelum, along which river the road lay for a great part of the distance. On the opposite bank dark shales, either Spiti or Sabáthu, were noticed between Raru and Tinali, and limestones opposite Uri. From Tinali to Hatian the general dip of the Mari beds is south-east: near Uri they are much contorted.

24th, Urambu.—Uri is on a high river plateau. After crossing a stream, very red shales are seen, and blocks of limestone, looking exactly like Krol limestone, which it probably is. I am not sure whether the shales are nummulitic: more probably they belong to the Krol series. Further on are chloritic and quartzose schists, which continue to Urumbu. The Urumbu bungalow is built at the foot of some very fine cliffs of a metamorphic quartz and schist.[3]

25th, Baramula.—The same metamorphic quartzose rock, with bacillary structure, continues a long way until the road opens into a portion of the old lake: this portion is separated by a ridge from 200 to 300 feet (high ?) of lake clay and gravel deposit. The same form the low hills to the south for several miles. The lake must formerly have been much larger and wider than it now is, its water extending far up the Sind valley.

July 26th to August 6th.—Baramula to Srinagar and thence to Gandarbal.—[No description is given in the diary of the rocks about Srinagar, although reference is made to

[1] Of Cutch.

[2] Records, Geological Survey of India, V, p. 15.

[3] Lydekker, Rec. G. S. I., IX, p. 158, describes this section more fully. The limestone (Kiol) appears to be identical with Krol, as Dr. Stoliczka suggested. See also Rec., G. S. I., XI, p. 62.

them subsequently.] Passing the village Malshabagh (near Gandarbal), I saw a sub-recent conglomerate, which was deposited fully 50 feet above the present level of the lake, and in places it was overlain by terraces of clay (level), which seemed to reach about 30 to 50 feet higher.

7th, Kangan.—The rocks on both sides of the road are the same as about Srinagar—the green plutonic rock, often with zeolite cavities, and sometimes not to be distinguished from greenstone. In other places it is distinctly stratified, and it is probably a metamorphic silurian or devonian rock.

8th to 12th, Kangan to Sonamarg.—[No mention of any geology on the road.] The triassic limestones come almost down to the valley about three miles before reaching Sonamarg. At Sonamarg they are in some parts rather slaty and thin-bedded: I got no fossils in them. They dip north and south on the right and left bank of the valley respectively.

13th, Baltal.—About four miles east of Sonamarg, schists below the limestones occupy the greater heights, particularly on the north, and they extend in a north-easterly direction along these heights. At Baltal all the rocks are these schists, which are probably carboniferous. They often contain carbonaceous bands full of crystals of iron pyrites.

14th, Mataian.—[Crossing the Zoji-la,[1] 11,800 feet.] The schistose beds, which are in places almost mica schist, are followed, a couple of miles north of the Zoji-la, by more carbonaceous beds, which are probably true carboniferous, and then, about a mile south of Mataian, they are overlain on the right and left bank by the usual thin-bedded triassic limestones. These are sometimes quite white and dolomitic, alternating with black and earthy beds. I saw several *Rhynconellæ* and sections of large bivalves, like *Megalodon* and *Dicerocardium*, and small oysters; but nothing sufficiently determinable. [Further examination of the beds near the Zoji-la has shown that there is inversion, and that the rocks at the crest of the pass are of later age than the triassic limestones seen on each side.—Lydekker, Rec. G. S. I., XI, p. 45.]

15th, Mataian.—I looked over the limestones near the village, but found no determinable fossils.

16th, Drás.—About three miles after we left Mataian the green rocks cut off the limestone on the left bank, and for a few miles the boundary between the two rocks runs in the valley. After about the seventh or eighth mile, the base of the valley is all of green rock, which is generally quite massive, like greenstone; only occasionally it is thinly bedded with bacillary structure. To all appearance they are the same rocks as about Srinagar. About two or three miles before reaching Drás, the green rocks cross over entirely on to the right bank, and extend in a north-easterly direction, the trias limestones keeping to the heights. At their contact with the green rocks the limestones are more slaty. North by west of Drás the green rocks decompose very readily, and weather out reddish, as greenstones often do. About the camping ground numbers of syenite rocks are strewn about. The whole plain about Drás is filled with a deposit of shingle to about a hundred feet above the level of the river.

17th, Tashgaon.—For some distance from Drás the rugged, barren hillsides consist of greenstone. This rock gradually passes into a greenish syenite, with large quantities of schorl; but on both sides of the valley there is still the green rock *in situ:* higher up on the left bank is syenite.

[1] *La*, a pass Tibetan.

18th, Chiliscomo.—The green rock becomes rather schistose about half-way between the last camp and this, and nearly opposite Kharbu the syenite comes down to the river, and cuts off the green rock: the former about here is light coloured and of the ordinary type.

19th, Kargil.—Syenite rocks seen the whole way.

20th, Shargol.—The tertiaries on the Kargil plain are much covered by diluvial conglomerate. The Pashkyumkur is built on serpentine rock; and from this spot to near Shargol all the rocks are serpentine, sometimes rather slaty and splintery, in other places much purer and solid, so that it could be worked for ordinary cups, &c. All along the river the diluvial conglomerate forms an almost continuous strip, particularly along the left bank of the stream.

Wherever the valley widens a little, as at Lotsun, the conglomerate is found on both sides, the horizontal banks rising up to 500 or 600 feet above the stream. About a mile from Shargol, grey and greenish and reddish shales come in from the hills to south-west and west, and are greatly developed north of Shargol. These shales appear to belong to the Sabáthu group, although they look rather metamorphic in some places, but in others they are more recent looking and micaceous. All about Shargol lumps of serpentine are sticking out of them, and the whole are covered along the left bank of the stream with a conglomerate rising to 600 and more feet above the river. Beyond this, south and south-east of Shargol, the higher hills all consist of triassic limestone, alternating near the base with rather highly metamorphic and sometimes strongly carbonaceous shales, which it is very difficult to distinguish from the tertiary beds. I found no trace of fossils in the tertiaries, but the determination of the triassic limestone is tolerably certain. It is the same as above Drás, and has often the peculiar pseudo-foraminiferous or semi-oolitic structure.

21st, Kharbu.—A good long march of 18 miles: we went by the Namika-la, and then turned almost south up the stream for about four miles to Kharbu. The diluvial conglomerate extends all the way along the river, mostly developed on the left bank, until we turned up the stream almost north and then north-east and east towards the Namika-la. A couple of miles from Shargol the monastery is built upon triassic limestone, and there are lumps and patches of it very often sticking out of the so-called tertiary shales. The great figure of Buddha a little further on is also cut in a single block of triassic limestone. When we left the conglomerates at the Wakha river, we turned almost north. There was nothing but very soft and crumbling grey and greenish (tertiary) shales as far as the Namika pass, and for some distance on the other side, extending more to north about two miles east of the pass; and the high hills to the north consisted of serpentine, while south of the Namika-la was a high solitary rock of trias limestone. The diluvial conglomerates were again seen in the little stream from the Namika-la, and are very highly developed in the Kharbu stream. Approaching this, we had up to Kharbu, along the right bank, all trias limestone, underlain by highly carbonaceous and metamorphic-looking shales and slates, which are always distinctly silky and micaceous on the planes of bedding, and often very much contorted.

22nd, Kharbu.—I went out in a north-easterly direction across the stream, and found the ground composed of various kinds of shales for several miles. First, the shales were rather carbonaceous; then they became more slaty, gray, greenish, and red, but all rather highly metamorphic. It is clear they cannot be tertiary; for they all lay under the trias. The top of the high hills appears to consist partly of serpentine. Among the higher slates there are often beds of the same green rock that I saw south of Drás.

23rd, Lamayuru, crossing the Fotu-la.—Leaving Kharbu, the triassic limestones pass over to the right bank of the stream after the second or third mile, where the stream makes a bend; but further on the carboniferous shales occupy the whole of the right and the base of the left bank, the limestones keeping to the greater heights. The diluvial conglomerate is locally of great extent; and in ascending the Fotu-la, it reaches to within about 200 feet of the top of the pass, that is, up to about 13,200. On the Fotu-la the southern hills are trias limestone. The pass itself is formed of carboniferous shales; and these shales extend down to Lamayuru. Unfortunately I could not find any fossils in them.

24th, Snurla on the Indus.—For more than a mile after leaving Lamayuru there are extensive shaly deposits, some of them well stratified; they reach to about 300 feet high on the slopes. The shales are at first in places very carbonaceous, and when decomposed they are covered with a white efflorescence of soda and alum. About two miles or a little more further on, these carbonaceous shales overlie nearly vertically bedded green and red shales; the latter alternate with beds of strong green sandstone, very similar to the "green-rock," and the whole group evidently represents the Bhabeh series, just as the former does the Muth series. In one place only I saw, in the Bhabeh slates, a bit of an impression, something like a portion of a *Trilobite;* and in another place I got a few traces of worms. These Bhabeh slates, shales, and sandstones are variously contorted, but for the most part approach the vertical position, dipping highly towards south or south-west. Towards the Indus the Bhabeh series is cut off by serpentines, which reach down to the valley. Only in one place, I think, there is a portion of syenite left, the ground about a mile from the Indus being strewn with boulders of syenite. The opposite bank of the Indus is occupied by greenish and reddish slates and sandstones—evidently the treacherous tertiary rocks, like in North Rupshú and Záskar. The bridge across the Indus to Khalchi is built over serpentine, and there are a good many patches of serpentine also on the right bank, and near these the sandstones and shales appear to be almost metamorphic. There is also, about half-way between Khalchi and Snurla, a lump or two of a grey or bluish limestone, full of bivalves. It looks triassic; still I do not know how it could be that. Fragments of it were locally full of large pelecypods and indistinct gastropod traces, and in some round rolled fragments I thought I saw nummulites, but I cannot be sure of it. Similar lumps of the same limestone I saw in the serpentine region before reaching the Indus, and it is just possible that some of the slates and sandstones here are really tertiary. I rather think this very probable. At Snurla the tertiary slates and shales, greenish and reddish beds alternating with each other, occupy both banks of the Indus, mostly dipping at high angles towards the south. Conglomerates are locally to be found reaching to a couple of hundred feet or less along the whole road.

25th, Saspúl.—All the way we passed through the tertiary red and greenish shales and sandstones, mostly along the strike of the rocks, which dip at a high angle of between 60° and 80° to south-west or south by west. The crystalline rocks appear to occupy the hills above Himis. Diluvial conglomerate is extensively developed along the river, and particularly about Saspúl.

25th and 26th, Saspúl to Leh.—The same rocks for the greatest part of the distance; the gneiss and hornblendic gneiss do not touch the river till just before Pittuk, beyond the village of Phayang. The diluvial deposits are very extensive, and are very thick just east of Snemo.

PART II.

The hill ranges between the Indus Valley in Ladák and Sháh-i-dula on the frontier of Yárkand territory.

[This section is copied, with a few verbal alterations, from the Records of the Geological Survey of India, Vol. VII, p. 12.]

The following brief notes on the general geological structure of the hill ranges alluded to are based upon observations made on a tour from Leh, *viâ* Changchenmo, the high plains of Lingzi-thung, Karatágh, Aktágh to Sháh-i-dula, and upon corresponding observations made by Dr. H. W. Bellew, accompanying His Excellency Mr. Forsyth's camp along the Karakoram route to this place.

Before proceeding with my account, I will only notice that our journey from Leh (or Ladák) was undertaken during the second half of September and in October, and that we found the greater portion of the country north of the Changchenmo valley covered with snow—the greatest obstacle a geologist can meet on his survey. While on our journey the thermometer very rarely rose during the day above the freezing point, and hammer operations were not easily carried out. At night the thermometer sank, as a rule, to zero, or even to 8° below zero, in our tents, and to 26° below zero in the open air. Adding to this the natural difficulties of the ground we had to pass through, it was occasionally not an easy matter to keep the health up to the required standard of working power.

Near Leh, and for a few miles east and west of it, the Indus flows on the boundary between crystalline rocks on the north and eocene rocks on the south. The latter consist chiefly of grey and reddish sandstones and shales, and more or less coarse conglomerates, containing an occasional *Nummulite* and casts of *Pelecypoda*. These tertiary rocks extend from eastward south of the Pankong lake, following the Indus either along one or both banks of the river, as far west as Kargil, where they terminate with a kind of brackish and fresh-water deposit, containing *Melaniæ*.

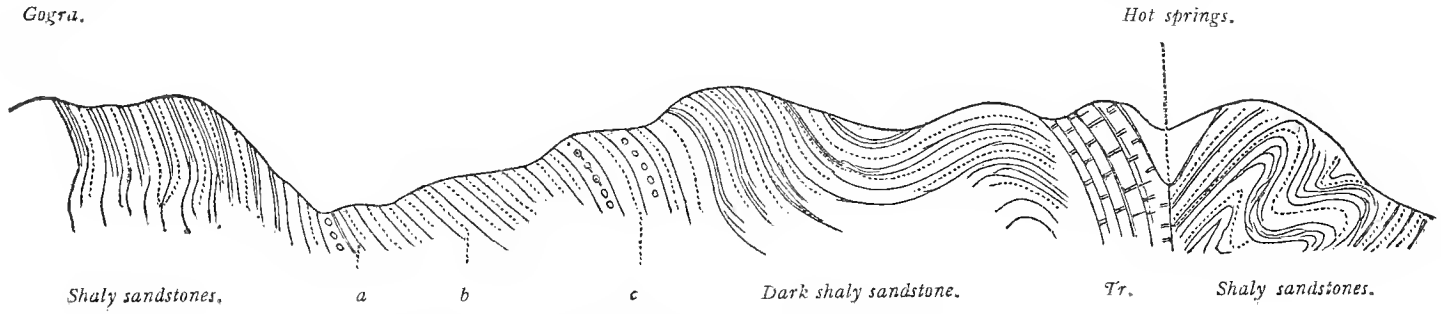
Nearly the entire ridge north of the Indus, separating this river from the Shayok, and continuing in a south-easterly direction to the mouth of the Hanle river (and crossing here the Indus, extending to my knowledge as far as Demchok), consists of syenitic gneiss, an extremely variable rock as regards its mineralogical composition. The typical rock is a moderately fine-grained syenite, crossed by veins which are somewhat richer in hornblende, while other portions contain a large quantity of schorl. Both about Leh and further eastward extensive beds of dark, almost black, fine-grained syenite occur in the other rock. The felspar often almost entirely disappears from this fine-grained variety, and quartz remains very sparingly disseminated, so that gradually the rock passes into a hornblendic schist; and when schorl replaces hornblende, the same rock changes into layers which are almost entirely composed of needles of schorl. Again, the syenite loses in places all its hornblende, the crystals of felspar increase in size, biotite (or sometimes chlorite) becomes more or less abundant, and with the addition of quartz we have before us a typical gneiss (or protogine gneiss), without being able to draw a boundary between it and typical syenite. However, the gneissic portions, many of which appear to be regularly bedded, are decidedly subordinate to the

syenitic ones. As already mentioned, the rock often has a porphyritic structure, and the felspar becomes pink, instead of white,—as, for instance, on the top of the Khardung pass and on the southern slope of the Chang-la, where large fragments are often met without the slightest trace of hornblende. To the north of the last-mentioned pass the syenitic gneiss gradually passes into thick beds of syenite-schist, and this again into chloritic schist, by the hornblende becoming replaced by chlorite, while the other mineral constituents are gradually almost entirely suppressed. The syenitic and chloritic beds alternate with quartzose schists of great thickness. The schistose series of rocks continues from north of the Chang-la to the western end of the Pankong lake, and northwards to the Lankar-la, generally called the Marsemik pass. On the western route Dr. Bellew met similar rocks north of the Khardung pass at the village Khardung, and traced them northwards across the Shayok up the Nubra valley to near the foot of the Sasser pass.

Intimately connected with the metamorphic schistose series just noticed is a greenish chloritic, partly thin-bedded, partly more massive rock, which very closely resembles a similar rock found about Srinagar. Only in this case certain layers, or portions of it, become often distinctly or even coarsely crystalline, sometimes containing bronzite sparingly disseminated, and thus passing into diallage. This chloritic rock forms the greater part of the left side of the Changchenmo valley, and also occurs south of the Sasser pass. I think we have to look upon this whole series of schistose and chloritic rocks as the representatives of the *silurian formation*.

After crossing the Changchenmo valley to Gogra, we met with a different set of rocks. They are dark, often quite black, shales, alternating with sandstones. Many beds of the latter have a comparatively recent aspect, and are rather micaceous, without the least metamorphic structure, while the shales accompanying them very often exhibit a silky, sub-metamorphic appearance on the planes of fracture. I observed occasionally traces of *fucoids* and other plants in these shales, but no animal fossils. On the Changchenmo route these shaly rocks form the ridge of the Chang-lung pass, as well as the whole of the western portion of the Lingzi-thung; and they are met again after crossing these high plains and entering the Karakásh valley, as far as Shinglung (or Dunglung). On the Karakoram route Dr. Bellew brought specimens of similar rocks from the Mastágh (Karakoram) range itself. There can be but little doubt,—judging from similar rocks which I saw in Spiti, and from their geological relation to certain limestones, of which I shall presently speak,—that we have in the shaly series the *carboniferous formation* represented.

In many localities along the right bank of the Changchenmo river, then at the hot springs north of Gogra, and on the southern side of the Chang-lung pass, we find the carboni-



Section of rocks at the hot springs of Gogra.

ferous beds overlain by *triassic limestone*, which often has the characteristic semi-oolitic structure of the Krol limestone, south of Simla. At Gogra and several other places dolomi-

tic beds occur; and, in these, sections of *Dicerocardium Himalayense* are not uncommon. In other places beds are met with full of Crinoid stems. North of the Lingzi-thung plain—to the west of which the hills are mostly composed of the same triassic limestone—a red brecciated, calcareous conglomerate is seen at the foot of the Compass-la, but this conglomerate gradually passes into the ordinary grey limestone, which forms the ridge, and undoubtedly belongs to the same group of triassic rocks. The last place where I saw the triassic limestone was just before reaching the camping ground Shinglung: here it is an almost white or light grey compact rock, containing very perfect sections of *Megalodon triqueter*, the most characteristic triassic fossil. On Mr. Forsyth's route Dr. Bellew met with similar triassic limestones on the northern declivities of the Sasser pass, and also on the Karakoram pass, overlying the carboniferous shales and sandstones previously noticed. On the Karakoram the triassic limestone contains spherical corals, very similar to those which were a few years ago described by Professor Ritter von Reuss from the Hallstadt beds in the Alps, and which are here known to travellers as Karakoram stones.[1]

Returning to our Lingzi-thung route, we leave, as already mentioned, the last traces of triassic limestone at Shinglung, in the Upper Karakásh valley. Here the limestone rests upon some shales, and then follow immediately the same chloritic rock which we noticed on the Lankar-la, alternating with quartzose schists, both of which must be regarded as of upper palæozoic age.

At Kizil-jilga regular sub-metamorphic slates appear, alternating with red conglomerate and red sandstones; and further on dark slate is the only rock to be seen the whole way down the Karakásh, until the river assumes a north-easterly course, some fourteen miles east of the Karatágh pass. From here my route lay in a north-westerly direction towards Aktágh, and the same slaty rock was met with along the whole of this route up to the last-mentioned place. Dr. Bellew also traced these slates from the northern side of the Karakoram to Aktágh. They further continue northwards across the Súget-lá, a few miles north of the pass, as well as in single patches down the Súget river to its junction with the Karakásh. The irregular range of hills to the south of the portion of the Karakásh river, which flows almost east and west from Sháh-i-dula, on its southern side entirely consists of these slates, while on the northern side it is composed of a fine-grained syenite, which also forms the whole of the Kuenluen range along the right bank of the Karakásh river, and also is the sole rock composing the hills about the camping ground at Sháh-i-dula. The slates of which I spoke are, on account of the close cleavage, mostly fine, crumbling, not metamorphic, and must, I think, be referred to the silurian group. They correspond to the metamorphic schists on the southern side of the Karakoram ranges.

Thus we have the whole system of mountain ranges between the Indus and the borders of Turkistan bounded on the north and south by syenitic rocks, including between them the silurian, carboniferous, and triassic formations.[2] This fact is rather remarkable, for, south of the Indus, we have nearly all the principal sedimentary formations represented, from the silurian up to the eocene, and most of the beds abound in fossils.

The only exception to which I can allude on the Changchenmo route is near Kium, in the Changchenmo valley. Here there are on the left bank of the river some remarkably

[1] We are still somewhat in the dark as to the true nature of these curious fossils. Dr. Waagen considered them allied to some sponges (*Astylospongia*) described by Professor Ferd. Römer from Tennessee and from the Silurian pebbles in the drift of Silesia, and certainly the resemblance externally and on cut sections is very great, but hitherto no spicules have been detected in the Karakoram stones. The specimens have now been sent to Europe for identification.

[2] On his subsequent journey from Yarkand, Dr. Stoliczka found that the highest portions of the Karakoram pass consist of liassic rocks (Tagling). See concluding portion of Geology, p. 45.

recent-looking sandstones and conglomerates, dipping at an angle of about 45° to north by east, and at the foot of these beds rise the hot springs[1] of Kium. I think it probable that this conglomerate has eastward a connection with the eocene deposits, which occur at the western end of the Pankong lake[2] and in the Indus valley south of it.

In the previous notes I have scarcely alluded to the dip of the rocks at the different localities. The reason is, that there is, indeed, very great difficulty in directly observing both the dip and the strike. At the western end of the Pankong lake the dip of the metamorphic schists is mostly south-westerly, but further on nearly all the rocks dip at a moderate angle to north-east, north by east, or to north. On the Lingzi-thung, just after crossing the Chang-lung, the shales are mostly highly inclined, but further on the limestones lie unconformably on them and dip to north-east. Wherever the hills consist merely of shales and slates, their sides are generally so thickly covered with debris and detritus, that it becomes almost an exception to observe a rock *in situ*.

The debris is brought down in large quantities by the melting snow into the valleys, and high banks of it are everywhere observable along the water-courses. At a somewhat remote—say diluvial—period this state of things has operated on a far greater scale. Not only were the lakes, like the Pankong, much more extensive, but valleys, like the Chang-chenmo, or the Tánkse valley, sometimes became temporarily blocked up by glaciers, or great landslips, and the shingle and clay deposits were often accumulated in them to a thickness of two or more hundred feet. Near Aktágh similar deposits of stratified clay exist of about 160 feet in thickness, and extend over an area of more than 100 square miles.[3] There can be but little doubt that when these large sheets of water were in existence, the climate of these now cold and arid regions was both milder and moister, and naturally more favourable to animal and vegetable life than it is now. A proof of this is given, for instance, by the occurrence of subfossil *Succineæ*, *Helices*, and *Pupæ* in the clay deposits of the Pankong lake, while scarcely any land mollusk could exist at the present time in the same place.

Note regarding the occurrence of jade in the Karakásh valley on the southern borders of Turkistan.

[From Records of the Geological Survey of India, Vol. VII, p. 51; and Quart. Jour. Geol. Soc., 1873, XXX, p. 568.]

The portion of the Kuenluen range which extends from Sháh-i-dula eastward towards Khotan appears to consist entirely of gneiss, syenitic gneiss, and metamorphic rocks, these being quartzose, micaceous, or hornblendic schists. On the southern declivity of this range, which runs along the right bank of the Karakásh river, are situated the old jade mines, or rather quarries, formerly worked by the Chinese. They are about 7 miles distant from the Kirghíz encampment Balakchi, which itself is about 12 miles south-east of Sháh-i-dula. I had the pleasure of visiting the mines in company with Dr. Bellew and Captain Biddulph, with a Yárkandi official as ourguide.

[1] The temperature of these hot springs varies from 60° to 125°. They form no deposit of gypsum, like the springs north of Gogra, but there is a good deal of soda deposit round them. (S).

[2] I can find no mention of any eocene deposits at the western end of the Pankong lake in the diary. Some deposits are noticed which contain fresh-water shales, but are evidently much more recent. Some recent-looking yellow conglomerate or coarse sandstone is mentioned in the Rimdi valley, north of the Pankong lake. There may be some mistake in the wording of the text here, due to its having been printed in Dr. Stoliczka's absence.

[3] For a description of the alluvial deposits of Ladák and the Upper Indus basin, see Drew, Quart. Jour. Geol. Soc., 1873, XXIX, p. 441.

We found the principal jade locality to be about 1½ miles distant from the river, and at a height of about 500 feet above the level of the same. Just in this portion of the range a few short spurs abut from the higher hills, all of which are, however, as usual, thickly covered with debris and sand—the result of disintegration of the original rock. The whole has the appearance of being produced by an extensive slip of the mountain-side. Viewing the mines from a little distance, the place seems to resemble a number of pigeon-holes worked in the side of the mountain, except that they are rather irregularly distributed. On closer inspection we saw a number of pits and holes dug out in the slopes, extending over a height of nearly a couple of hundred feet, and over a length of about a quarter of a mile. Each of these excavations has a heap of fragments of jade and rock at its entrance. Most of them are only from 10 to 20 feet high and broad, and their depth rarely exceeds 20 or 30 feet; only a few show some approach to low galleries of moderate length, and one or two are said to have a length of 80 or 100 feet. Looking on this mining operation as a whole, it is no doubt a very inferior specimen of the miners' skill; nor could the workmen have been provided with any superior instruments. I estimated the number of holes at about a hundred and twenty; but several had been opened only experimentally—an operation which had often to be resorted to on account of the superficial sand concealing the underlying rock. Several pits, also, which were probably exhausted at a moderate depth, had been again filled in; their great number, however, clearly indicates that the people had been working singly, or in small parties.

The rock, of which the low spurs at the base of the range are composed, is partly a thin-bedded, rather sandy, syenitic gneiss, partly mica and hornblendic schist. The felspar gradually disappears entirely in the schistose beds, which on weathered planes often have the appearance of a laminated sandstone. They include the principal jade-yielding rocks, being traversed by veins of a pure white, crystalline mineral, varying in thickness from a few feet to about forty, and perhaps even more. The strike of the veins is from north by west to south by east, or sometimes almost due east and west; and their dip is either very high towards north, or they run vertically. I have at present no sufficient means to ascertain the true nature of this vein rock, as it may rather be called, being an aggregate of single crystals.[1] The mineral has the appearance of albite, but the lustre is more silky, or perhaps rather glassy, and it is not in any way altered before the blowpipe, either by itself or with borax or soda. The texture is somewhat coarsely crystalline, rhombohedric faces being on a fresh fracture clearly traceable. It sometimes contains iron pyrites in very small particles, and a few flakes of biotite are also occasionally observed. This white rock is again traversed by veins of nephrite, commonly called jade; which, however, also occurs in nests. There appear to be two varieties of it, if the one, of which I shall presently speak, really deserves the name of jade. It is a white tough mineral, having an indistinct cleavage in two different directions, while in the other directions the fracture is finely granular or splintery, as in true nephrite. Portions of this mineral, which is apparently the same as that usually called white jade, have sometimes a fibrous structure. This white jade rarely occupies the whole thickness of a vein; it usually only occurs along the sides in immediate contact with the white vein rock, with which it sometimes appears to be very closely connected. The middle part of some of the veins, and the greater portion of others, consist entirely of the common

[1] The only specimen in the collection made by Dr. Stoliczka at this place which agrees with his description proves to be dolomite.

green jade, which is characterised by a thorough absence of cleavage, great toughness, and rather dull vitreous lustre. The hardness is always below 7, generally only equal to that of common felspar, or very little higher, though the polished surface of the stone appears to attain a greater hardness after long exposure to the air. The colour is very variable, from pale to somewhat darker green, approaching that of pure serpentine. The pale-green variety is by far the most common, and is in general use for cups, mouth-pieces for pipes, rings and other articles used as charms and ornaments. I saw veins of the pale green jade amounting in thickness to fully 10 feet; but it is by no means easy to obtain large pieces of it, the mineral being generally fractured in all directions. Like the crystalline vein-mineral, neither the white nor the green variety of jade is affected by the blowpipe heat, with or without addition of borax or soda. Green jade of a brighter colour and higher translucency is comparatively rare, and, on that account, no doubt much more valuable. It is usually only found in thin veins of one or a few inches; and even then it is generally full of flaws.

Since the expulsion of the Chinese from Yárkand in 1864, the jade quarries in the Karakásh valley have become entirely deserted. They must have yielded a considerable portion of the jade of commerce; no doubt the workmen made a good selection on the spot, taking away only the best coloured and largest pieces; for even now a great number of fair fragments, measuring 12 to 15 inches in diameter, form part of the rubbish thrown away as useless.

The Balakchi locality is, however, not the only one which yielded jade to the Chinese. There is no reason to doubt the existence of jade along the whole of the Kuenluen range, as far as the mica and hornblendic schists extend. The great obstacle in tracing out the veins, and following them when once discovered, is the large amount of superficial debris and shifting sand which conceal the original rock *in situ*. However, fragments of jade may be seen among the boulders of almost every stream which comes down from the range. We also observed large fragments of jade near the top of the Sanju pass, which, on its southern side at least, mostly consists of thin-bedded gneiss and hornblendic schist.

Another rich locality for jade appears to exist somewhere south of Khotan, from whence the largest and best coloured pieces are said to come; most of them are stated to be obtained as boulders in a river bed, though this seems rather doubtful. Very likely the Chinese worked several quarries south of Khotan, similar to those in the Karakásh valley, and most of the jade from this last locality was no doubt brought into Khotan, this being the nearest manufacturing town. A great number of the better polished ornaments, such as rings, &c., sold in the bazar of Yárkand, have the credit of coming from Khotan; possibly they are made there by Chinese workmen, but the art of carving seems to have entirely died away, and indeed it is not to be expected that such strict Mahomedans as the Yárkandees mostly are would eagerly cultivate it. If the Turkistan people will not take the opportunity of profiting by the export of jade, or if no new locality of that mineral is discovered within Chinese territory, the celestial people will feel greatly the want of the article, and good carved specimens of jade will become great rarities. The Chinese seem to have been acquainted with the jade of the Kuenluen mountains for the last two thousand years, for Khotan jade is stated[1] to be mentioned "by Chinese authors in the time of the dynasty under Wuti (B. C. 148—86)."

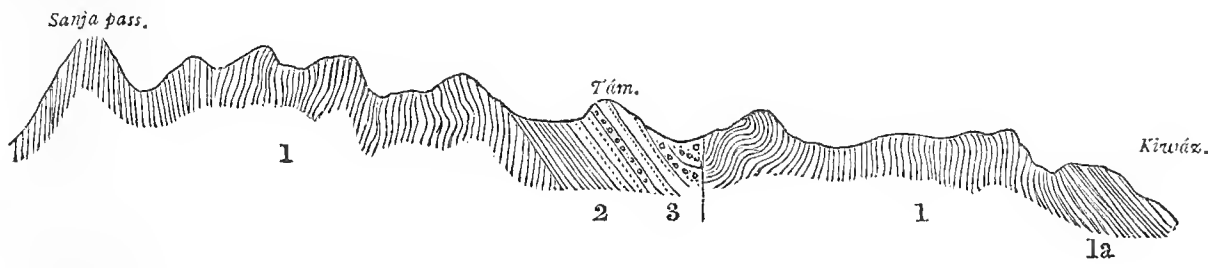
[1] Yule's Marco Polo, Vol. I, p. 177. (S.)

PART III.

From Sháh-i-dula to Yárkand and Káshghar.

[From Records of the Geological Survey of India, Vol. VII, p. 49; and Quart. Jour. Geol. Soc., 1874, Vol. XXX, p. 571.]

In a former communication I had already occasion to notice, that the rocks composing the Kuenluen range near Sháh-i-dula chiefly consist of syenitic gneiss, often interbedded, and alternating with various metamorphic and quartzose schists. Similar rocks continue the whole way down the Karakásh river for about 24 miles. After this the road follows, in a somewhat north-westerly direction, a small stream leading to the Sanju (or Grim) pass. Here the rocks are chiefly true mica schist, in places full of garnets. Near the summit, and on the pass itself, chloritic and quartzose schists prevail, in which veins of pale-green jade occur, numerous blocks containing this mineral having been observed near the top of the pass. All the strata are very highly inclined, often vertical, the slopes of the hills, and in fact of the entire range, being on that account rather precipitous, and the crests of the ridges themselves very narrow.



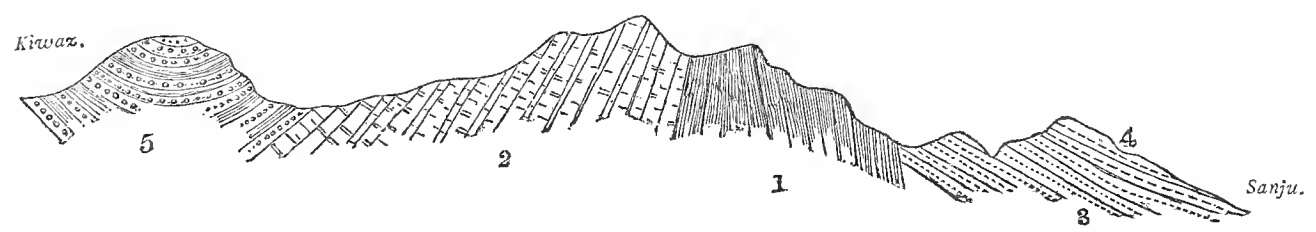
1. Metamorphic rocks. 1a. Submetamorphic schists. 2. Slates. 3. Sandstones and conglomerates.

Section from the Sanju Pass to Kiwáz.

To the north of the Sanju pass we again meet with metamorphic, mostly chloritic schists, until we approach the camping place Tám, where distinctly bedded sedimentary rocks cap the hills of both sides of the valley. They are dark, almost black, silky slates, resting unconformably on the schists, and are overlain by a grey, partly quartzitic sandstone, passing into conglomerate. The last rock contains particles of the black slates, and is, therefore, clearly of younger age. Some of the conglomeratic beds have a remarkably recent aspect, but others are almost metamorphic. In none of the groups, the slates or sandstones or conglomerates, have any fossils been observed; but they appear to belong to some palæozoic formation. They all dip at from 40° to 50° towards north-east, extending for about $1\frac{1}{2}$ miles down the Sanju valley. Here they are suddenly cut off by metamorphic schists, but the exact place of contact on the slopes of the hills is entirely concealed by debris. The schists are only in one or two places interrupted by massive beds of a beautiful porphyritic gneiss, containing splendid crystals of orthoclase and biotite; they continue for about 18 miles to the camp Kiwáz. On the road, which often passes through very narrow portions of the valley, we frequently met with old river deposits, consisting of beds of gravel and very fine clay, which is easily carried off by only a moderate breeze, and fills the atmosphere with clouds of dust. These old river deposits reach in many places up to about 150 feet

above the present level of the river, which has to be waded across at least once in every mile.

At the camp, Kiwáz, the hills on both sides of the valley are low, composed of a comparatively recent-looking conglomerate, which in a few places alternates with beds of reddish, sandy clay, the thickness of the latter varying from 2 to 5 feet only. These rocks strikingly resemble those of the supra-nummulitic group, so extensively represented in the neighbourhood of Mari. They decompose very readily, covering the slopes of the mountains with loose boulders and sand, under which very little of the original rock can be seen. Near the camp the beds dip at about 40° to north-east, but about one mile and a half further on a low gap runs parallel to the strike, and on the other side of it the beds rise again, dipping with a similar angle to south-west, thus forming a synclinal at the gap. Below the conglomerate there crops out a grey, often semi-crystalline limestone,[1] containing in some of its thick layers large numbers of Crinoid stems, a *Spirifer*, very like *S. striatus*, and two species of *Fenestellæ*. Following the river to north by east, this carboniferous limestone again rests on chloritic schist, which, after a mile or two, is overlain by red sandstone, either in horizontal or very slightly inclined strata. Both these last-named rocks are very friable, easily crumbling between the fingers, particularly the latter, from which the calcareous cement has been almost entirely dissolved out. At Sanju the red sandstones underlie coarse grey calcareous sandstones and chloritic marls, some beds of which are nearly exclusively composed of *Gryphæa vesiculosa*,[2] many specimens of this most characteristic middle cretaceous fossil being of enormous size. The *Gryphæa* beds and the red sandstones are conformable to each other; and although I have nowhere seen them interstratified near their contact, there is strong evidence of their being both of cretaceous age. Both decompose equally easily, and the *Gryphæa* beds have indeed in many places been entirely denuded. They have supplied the greater portion of the gravel and beds of shifting sand, which stretch in a north-easterly direction towards the unknown desert land.



1. Chloritic schist. 2. Carboniferous limestone. 3. Red sandstone. 4. Sandstones and marls with *Gryphæa vesiculosa*. 5. Conglomerate with reddish clay (? tertiary).

Section from Kiwáz to Sanju, distance about 2 miles.

On the road from Sanju to Yárkand, which first passes almost due west, and after some distance to north-west, we crossed extensive tracts of these gravel beds, and of low hills almost entirely composed of clay and sand, though we only skirted the true desert country. Locally, as, for instance, near Oi-toghrak and Bora, pale reddish sandstones crop out from under the more recent deposits, but they appear to be newer than the cretaceous red sandstones, underlying the *Gryphæa* beds: the former most probably belong to some upper

[1] This carboniferous limestone had been previously noticed by Dr. Henderson, who gave a sketch of the section: "Lahore to Yárkand," p. 107.

[2] *G. vesicularis* in the original; but as this is an upper cretaceous species, and the specimens resemble *G. vesiculosa*, I think the latter is the name which Dr. Stoliczka intended to use.

tertiary group.[1] Among the sandy and clayey deposits I was not a little surprised to find true *Loess*, as typical as it can anywhere be seen in the valleys of the Rhine or of the Danube. I might even speak of "Berg" and "Thal-Löss," but I shall not enter into details on this occasion, for I may have a much better opportunity of studying this remarkable deposit. At present I will only notice that commonly we meet with extensive deposits of *Loess* only in the valleys. Its thickness varies in places from 10 to 80 and more feet—a fine yellowish *unstratified* clay, occasionally with calcareous concretions and plant fragments. In Europe the origin of this extensive deposit was, and is up to the present date, a disputed question. Naturally, if a geologist is not so fortunate as to travel beyond the "Rhein-" or "Donau-thal," and is accustomed to be surrounded with the verdant beauty of these valleys, he might propose half a dozen theories; and, as he advances in his experience, disprove the probability of one after the other, until his troubled mind is wearied of prosecuting the object further. Here in the desert countries, where clouds of fertile dust replace those of beneficial vapour, where the atmosphere is hardly ever clear and free from sand, nay occasionally saturated with it,—the explanation that the *Loess is a subaërial deposit* is almost involuntarily pressed upon one's mind. I do not think that by this I am advancing a new idea; for, unless I am very much mistaken, it was my friend Baron Richthofen who came to a similar conclusion during his recent sojourn in Southern China.

Yárkand lies about 5 miles from the river, far away from the hills, in the midst of a well cultivated land, intersected by numerous canals of irrigation; a land full of interest for the agriculturist, but where the geological mind soon involuntarily falls into repose. And what shall I say of our road from Yárkand to Káshghar? Little of geological interest, I am afraid.

Leaving Yárkand, we passed for the first few miles through cultivated land, which, however, soon gave way to the usual aspect of the desert, or something very little better. A few miles south-west of Kokrabát a low ridge runs from south-east to north-west. If we are allowed to judge from the numerous boulders of red sandstone and *Gryphæa* marl, some of considerable size and scarcely river-worn, we might consider the ridge as being composed of cretaceous rocks. But one hardly feels consoled with the idea that in wading through the sand he is only crossing a former cretaceous basin, and that the whole of this country has remained free from the encroachment of any of the cænozoic seas. It is very dangerous to jump to conclusions regarding the nature of ground untouched by the geological hammer. The answer to any doubt must for the present remain a desideratum.

On the fourth day of our march, approaching Yangihissár, we also crossed a few very low ridges; but these consisted entirely of gravel and marly clay beds, most of them dipping with a very high angle to south by east, the strike being nearly due east and west. South of Yangihissár the ridge bent towards south-west, and there was also a distant low ridge traceable in a north-easterly direction, the whole having the appearance of representing the shore of some large inland water-sheet. From Yangihissár to Káshghar we traversed only low land, usually more or less thickly covered with a saline efflorescence, but still to a considerable extent cultivated.

[1] From a note in the diary of May 31st, made on the return journey from Yárkand, it appears that Dr. Stoliczka ultimately considered these rocks the equivalents of some examined north of Káshghar, which he termed Artysh beds.

PART IV.

Geological observations made on a visit to the Chadyr-kul, Thian Shan Range.

[From Records of the Geological Survey of India, Vol. VII, p. 18; and Quart. Jour. Geol. Soc., 1874, Vol. XXX, p. 174.]

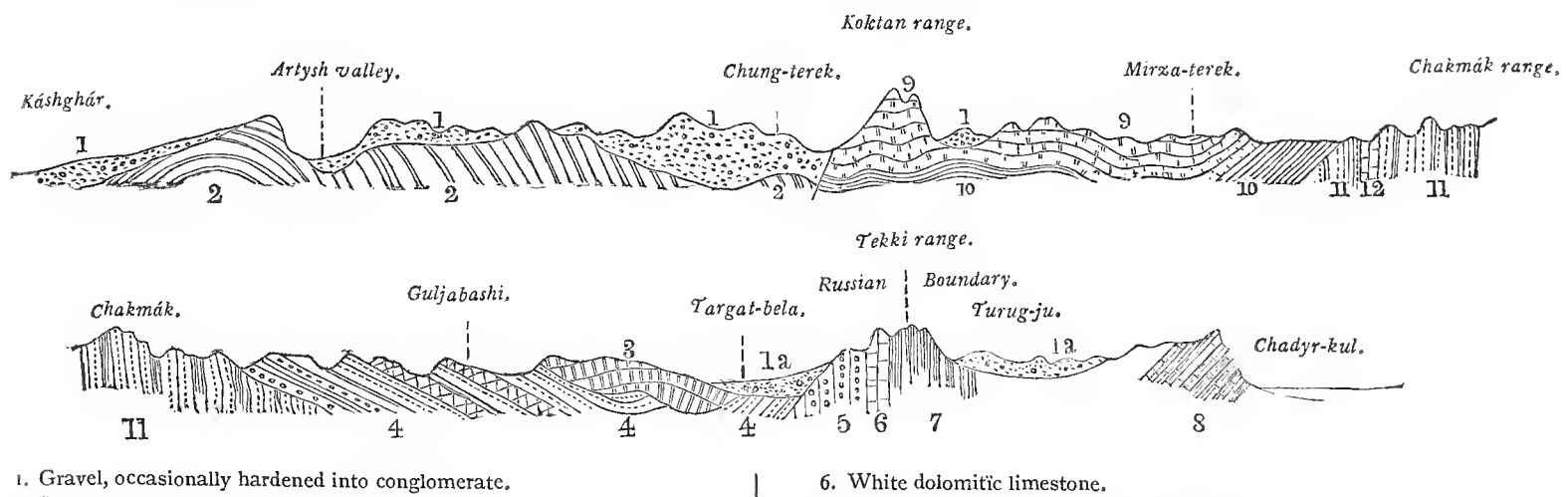
After a stay of nearly a month in our embassy quarters at Yangishahr, near Káshghar, the diplomacy of our envoy secured us the Amir's permission for a trip to the Chadyr-kul, a lake situated close on the Russian frontier, about 112 miles north by west of Káshghar, among the southern branches of the Thian Shan range. Under the leadership of Colonel Gordon, we—Captain Trotter and myself—left Yangishahr about noon on the last day of 1873, receiving the greeting of the new year in one of the villages of the Artysh valley, some 35 miles north-west from our last quarters. On the 1st of January 1874 we marched up the Toyanda river for about 20 miles to a small encampment of the Kirghiz, called Chung-terek; and following the Toyanda, and passing the forts Mirza-terek and Chakmák, we camped on the fifth day at Turgat-bela, about 11 miles south of the Turgat pass, beyond which, 5 miles further on, lies the Chadyr-kul. On the sixth we visited the lake, and on the day following retraced our steps, by the same route we came, towards Káshghar, which we reached on the 11th January.

Having had a day's shooting at Turgat-bela, and one day's halt with the King's obliging officers at the Chakmák fort, we were actually only nine days on the march, during which we accomplished a distance of about 224 miles. It will be readily understood that, while thus marching, there was not much time to search for favourable sections in out-of-the-way places, but merely to note what was at hand on the road. I can therefore only introduce my geological observations as passing remarks.

Leaving the extensive loess deposits of the valley of the Káshghar Daria, the plain rises very gradually towards a low ridge, of which I shall speak as the Artysh range. It is remarkably uniform in its elevation, averaging about 400 feet, somewhat increasing in height towards the west and diminishing towards the east, which direction is its general strike. This range separates the Káshghar plain from the valley of the Artysh river, which cuts through the ridge about 8 miles nearly due north of the city. Viewed from this, the entire ridge appears very regularly furrowed and weather-worn on its slope, indicating the softness of the material of which it is composed. One would, however, hardly have fancied that it merely consists of bedded clay and sand, mostly yellowish white, occasionally reddish, and sometimes with interstratified layers of greater consistency, hardened by a calcareous or silicious cement. On the left bank, in the passage of the river through the ridge, the beds appear in dome shape, gently dipping towards the Káshghar plain on one side, and with a considerably higher angle into the Artysh valley on the other. On the right bank at the gap all the exposed beds dip southward, those on the reverse of the anticlinal having been washed away by the Artysh river up to the longitudinal axis, and thus exposing almost vertical faces. These remarkably homogeneous clayey and sandy beds may appropriately be called *Artysh beds;* and although I could nowhere find a trace of a fossil in them, it seems to me very probable that they are of marine origin and of neogene age.

The southern slopes of the ridge are on their basal half entirely covered with gravel, which in places even extends to the top, assuming here a thickness of from 10 to 15 feet. Locally the gravel beds are separated from the main range by a shallow depression, forming a low ridge which runs along the base of the higher one, and from which it is, even in the distance, clearly discernible by its dark tint. The pebbles in the gravel are mostly of small size and well river-worn; they are derived to a very large extent from grey or greenish sandstones and shales, black or white limestone, more rarely of trap, basalt, and of gneiss. With the exception of the last-named rock, all the others had been met with *in situ* in the Upper Toyanda valley. The pieces of gneiss belong to a group of metamorphic rock which is usually called *Protogine*. It is mainly composed of quartz and white or reddish orthoclase, with a comparatively small proportion of a green chloritic substance. The white felspar variety generally contains as an accessory mineral schorl, in short, rather thick, crystals. I shall subsequently allude to the probable source from which the protogine pebbles might have been derived.

From Artysh we marched, as already stated, northwards, up the Toyanda river, and for the next 22 miles one was surprised to find nothing but the same Artysh and gravel deposits, the former constantly dipping at a high angle to north by west, and the latter resting on them in slightly inclined or horizontal strata; while among the recent river deposits in the bed of the valley itself the order of things appeared reversed. The gravels, having first yielded to denudation, here underly the clays derived from the Artysh beds, thus preparing an arable ground for the agriculturist, whenever a favourable opportunity offers itself. A few miles south of Chung-terek, the laminated Artysh beds entirely disappear under the gravel, which from its greater consistency assumes here the form of a rather tough, coarse conglomerate. In the bend of the river the latter has a thickness of fully 200 feet, and is eroded by lateral rivulets into remarkably regular Gothic pillars and turrets. It is rare to meet with a more perfect imitation of human art by nature. The general surface of the gravel deposits is comparatively low, from 400 to 500 feet above the level of the river; it is much denuded and intersected by minor streams and old water-courses.



1. Gravel, occasionally hardened into conglomerate.
1a. Limestone gravel.
2. Yellowish and reddish sandy and clay beds (Artysh beds).
3. Basalt.
4. Tertiary sandstones and conglomerates, red or white, with bands of doleritic and greenstone rocks interstratified.
5. Bedded limestone conglomerates.
6. White dolomitic limestone.
7. Dark semi-metamorphic schists and slates.
8. Dark limestone.
9. Blackish triassic limestone.
10. Triassic? greenish shales below the limestone.
11. Palæozoic shales, slates and sandstones.
12. A band of white and reddish crystalline limestone.

Section from Káshghar to the Chadyr Lake.

At a couple of miles north of Chung-terek the Koktan range begins with rather abrupt limestone cliffs, rising to about 3,000 feet above the level of the Toyanda. Nearly in the mid-

dle of it are situated the forts Mirza-terek and Chakmák, some ten miles distant from each other. The southern portion of this range consists at its base of undulating layers of greenish or purplish shales, overlain by dark-coloured, mostly black, limestone in thick and thin strata, the latter being generally earthy. The limestone occupies all the higher elevations, and, as is generally the case, greatly adds to the ruggedness of the mountains. About 5 miles north of Chung-terek, I found in a thick bed of limestone an abundance of *Megalodon triqueter*, a large *Pinna*, a *Spiriferina* of the type of *S. stracheyi*, blocks full of *Litho-dendron* corals, and numerous sections of various small *Gastropoda*. Thinner layers of the same limestone were full of fragments of Crinoid stems, and of a branching *Ceriopora*, the rock itself bearing a strong resemblance to the typical St. Cassian beds. In this place the shales, underlying the limestone, were partly interstratified with it, in layers of from 5 to 10 feet; and from this fact it seems to me probable that they also are of triassic age, representing a lower series of the same formation.

Proceeding in a north-westerly direction, the *Megalodon* limestones are last seen near Mirza-terek. From this place the greenish shales continue for a few miles further on, much disturbed and contorted; and at last disappear under a variety of dark-coloured shales, slates, and sandstones, with occasional interstratified layers of black, earthy limestone. The strike of the beds is from east by north to west by south, and the dip either very high to north or vertical. At Chakmák the river has cut a very narrow passage through these almost vertical strata, which rise precipitously to about 3,000 feet, and to the south of the fort appear to be overlain by a lighter-coloured rock. It is very difficult to say what the age of these slaty beds may be, as they seem entirely unfossiliferous, and we can at present only regard them as representing, in all probability, one of the palæozoic formations.

About 5 miles north-west of Chakmák a sensible decrease in the height of the range takes place, and with it a change in the geological formation. The palæozoic beds, although still crossing the valley in almost vertical strata, become very much contorted; while, unconformably on them, rest reddish and white sandstones and conglomerates, regularly bedded, and dipping to north-west with a steady slope of about 40 degrees. The rocks, though evidently belonging to a comparatively recent (cænozoic) epoch, appear to be much altered by heat, some layers having been changed into a coarse grit, in which the cement has almost entirely disappeared. I have not, however, observed any kind of organic remains in them. A little distance further on, they several times alternate with successive, conformably bedded, doleritic trap. The rock is either hard and compact, being an intimate, rather fine-grained mixture of felspar and augite in small thin crystals, or it decomposes into masses of various greenish and purplish hues, like some of the basic greenstones.

After leaving the junction of the Suyok and Toyanda (or Chakmák) rivers, and turning northwards into the valley of the latter, the panorama is really magnificent. Shades of white, red, purple, and black compete with each other in distinctness and brilliancy, until the whole series of formations appears in the distance capped by a dark-bedded rock.

Although, judging from the greater frequency of basaltic boulders, we already knew that this rock must be found further north, we hardly realised the pleasant sight which awaited us on the march of the 4th January, after having left our camp at Gulja, or Bokum-bashi. The doleritic beds increased step by step in thickness, and after a few miles we passed through what appeared to be the centre of an extensive volcanic eruption. Along the banks of the river columnar and massive basalt was noticed several times, with occasional small heaps of slags and scoriæ, among a few outcrops of very much altered and disturbed

strata of red or white sandstone, thus adding to the remarkable contrast of the scene. In front of us, and to the right, stretched in a semicircle a regular old Somma; the almost perpendicular walls rising to about 1,500 feet above the river, and clearly exposing the stratification of the basaltic flows, which were successively dipping to north-east, east, and south-east. On our left, as well as in an almost due western direction, portions of a similar Somma were visible above the sedimentary rocks, all dipping in the opposite way from those ahead of us. The cone itself has in reality entirely disappeared by subsidence, and the cavity was filled with the rubbish of the neighbouring rocks.

Passing further north we crossed a comparatively low country, studded with small rounded hills and intercepted by short ridges, with easy slopes; the average height was between 12,000 and 13,000 feet. This undulating high plateau proved to be one of the head-quarters of the *Kulja* (*Ovis karelini*), chiefly on account of the very rich grass vegetation which exists here. For this the character of the soil fully accounts. The entire ground was shown to consist of limestone gravel and pebbles of rather easily decomposing rocks, mixed with the ashes and detritus, evidently derived from the proximity of the volcanic eruption. Only rarely was an isolated basaltic dyke seen, or the tertiary sandstone cropping out from under the more recent deposits.

Viewing the country from an elevated position near our camp at Turgat-bela, the conglomerate and gravel beds, well clad with grass vegetation, were seen to stretch far away eastwards, and in a north-easterly direction across the Turgat pass; while on the south they were bounded by a continuation of the somewhat higher basaltic hills. Towards the west I traced them for about 7 miles, across a low pass at which a tributary of the Toyanda rises in two branches; while on the other side two similar streams flow west by south to join the Suyok river. To the north the proximity of a rather precipitously rising range shut the rest of the world out of view. For this ridge the name Terak-tagh of Humboldt's map may be retained; its average height ranges between about 16,000 and 17,000 feet. In its western extension it runs almost due east and west, composed at base of a tough limestone conglomerate of younger tertiary origin, followed by white dolomitic limestones, and then by a succession of slaty and dark limestone rocks, the former occasionally showing distinct signs of metamorphism, and changing into schist. All the beds are nearly vertical or very highly inclined, dipping to north by west, the older apparently resting on the younger. North of Turgat-bela the range makes a sudden bend in an almost northerly direction, and continues to the Chadyr-kul, where it forms the southern boundary of the lake plateau. By this time the white dolomitic, and afterwards the slaty beds, have entirely disappeared, and with them the height has also diminished. A comparatively low and narrow branch of the range which we visited consists here entirely of dark limestone, which in single fragments is not distinguishable from the trias limestone of the Koktan mountains, but here it does not contain any fossils. The ridge itself, after a short stretch in a north-east by north direction, gradually disappears under the much newer conglomeratic beds.

Across the Chadyr-kul plain the true Thian Shan range was visible, a regular forest of peaks seemingly of moderate and tolerably uniform elevation. The rocks all exhibited dark tints, but most of them, as well as the hills to the west of the Chadyr-kul, near the sources of the Arpa, were clad in snow. The lake itself was frozen, and the surrounding plain covered with a white sheet of saline efflorescence.

Brief sketch of the geological history of the hill ranges traversed.—In order that the preceding remarks may be more easily understood, I add a few words regarding the changes

which appear to have taken place at the close of the cænozoic epoch within the southern offshoots of the Thian Shan which we visited.

Short as our sojourn in the mountains was, it proved to be very interesting and equally instructive. Humboldt's account of the volcanicity of the Thian Shan, chiefly taken from Chinese sources, receives great support; but we must not speculate further beyond confiding in the expectation that both meso- and cænozoic rocks will be found amply represented in it.

As far as our present researches on the physical aspect of the country extend, we may speak of three geologically different ranges: the *Terek range*, which is the northernmost, the *Koktan* in the middle, followed by the *Artysh range*, below which begins the Káshghar plain. All three decrease in the same order in their absolute height, the last very much more so than the middle one. The first consists of old sedimentary rocks, the second of similar rocks in its southern parts, while younger tertiary and basaltic rocks occupy the northern portions; the third is entirely composed of young tertiary deposits. The general direction of all the ranges is from west to east, or nearly so: this direction evidently dating from the time when the whole of the Thian Shan chain was elevated. The undulating high plateau between the Terek and the Koktan is, near Turgat-bela, about 8 miles wide, the distance between the two ranges diminishing westward, while in the opposite direction it must soon more than double. Judging from the arrangement of the pebbles, which, as already noticed, are half derived from limestone, the direction of the old drainage must have been from west to east, and must have formed the head-waters of the Aksai river, which on the maps is recorded as rising a short distance east of the Chadyr-kul. Similarly, the gravel valley between the Koktan and Artysh ranges indicates a west to east drainage, and its width appears to have approximately averaged 20 miles. About 3 miles north of Chung-terek a secondary old valley exists, also extending from west to east, and is diametrically cut across by the Toyanda river. In this valley, which was formerly tributary to the one lying more southward, the gravel beds accumulated to a thickness of fully 100 feet. As the Artysh range did not offer a sufficiently high barrier, masses of the gravel passed locally over it or through its gaps into the Káshghar plain, which itself at that time formed a third large broad valley.

Thus, at the close of the volcanic eruptions in the hills north of Chakmák, we find three river systems all flowing eastward, and made more or less independent of each other by mountain ranges, about which it would, however, not be fair to theorise (in the present state of our knowledge) on the causes of their assumed relative position. It must have been at that time that the pebbles of protogine were brought down from some portion of the hills lying to the west; and it would be interesting to ascertain whether or not this rock is anywhere in that direction to be met with *in situ*.[1] When the turbulent times of Vulcan's reign became exhausted and tranquillity was restored, the whole country south of the axis of the

[1] In Severtzof's journey to the western portion of the Thian Shan (Jour. Roy. Geogl. Soc., 1870, pp. 352, &c.) metamorphic rocks are stated to be largely developed in the ranges further to the north-west. A large tract of geologically unexplored mountains intervenes, however, between the southern limits of Severtzof's examination and the Chadyr-kul. Baron Osten-Sacken's journey *viâ* the Chadyr-kul, from Vernoye to the neighbourhood of Káshghar (Jour. Roy. Geogl. Soc., 1870, p. 250), contains scarcely any information as to the geology of the countries traversed. He does not even notice the volcanic rocks south of the Chadyr-kul. See remarks at the end of Part V, p. 33.

It is perhaps as well to point out here, what will probably have occurred to many geologists who have read thus far. The geological school to which Dr. Stoliczka belonged has not, I believe, accepted the views prevalent amongst most English geologists as to the extent of subaërial denudation. It is far from improbable that some of the geological phenomena attributed by Dr. Stoliczka to subsidence might by other observers be considered as a simple effect of disintegration and removal by rain-water.

Thian Shan must have greatly subsided, and the wider the valleys, the more effectively was the extent of subsidence felt. To support this idea by an observation, I may notice that north of Chung-terek, at the base of the Koktan range, the Artysh beds have entirely disappeared in the depth, and the gravel beds overlying them dip partially under the Trias limestone,—a state of things which cannot be explained by denudation, but only by subsidence and consequent overturning of the older beds above the younger ones. A similar state of things is to be observed on the Terek range, where the young tertiary limestone conglomerate is in some places of contact overlain by the much older dolomite. Now, if the broad valley of the Káshghar plain sank first, and gradually lowest, as it in all probability did, we find a more ready explanation of the large quantities of loose gravel pouring into it and accumulating at the base of the Artysh range.

The sinking in of the volcanic centre north-west of Chakmák first appears to have drained off the former head of the Aksai river, making it the head of the Toyanda instead; and to the north of the Terek ridge it was most probably the cause of the origin of the Chadyr-kul. The subsidence of the country followed in the south, making it possible for the united Suyok and Toyanda rivers to force their passage right across the Koktan range, strengthen the Artysh river, cut with facility through the Artysh range, and join the Káshghar Daria. While thus indicating the course of the comparatively recent geological history of the ground, it must be, however, kept in mind that this change in the system of drainage had no essential effect upon the direction of the hill ranges. This, dating from much older times, was mainly an east-westerly one, following the strike of the rocks which compose the whole mountain system.

PART V.

Altyn-Artysh.

[From the Records of the Geological Survey of India, Vol. VIII, p. 13.]

Under the personal guidance of the Envoy, we—Dr. Bellew, Captain Chapman, Captain Trotter, and myself—left Yangishahr on the 14th of February, reaching Altyn-Artysh at a late hour the same day. A halt of two days was desirable to enable us to make all necessary arrangements for our further movements. However, before I proceed, I shall endeavour to give the reader an idea of the geographical position and limits of the country, of which I shall speak in the subsequent lines.

The data are derived from a general survey by Captain Trotter, and from information given by the Hakim Mahomed Khoja.

Altyn-Artysh, which is the chief place of the province, lies approximately about 23 miles north by east of Yangishahr. It is situated in the western part of the Yilak[1] on the Bogoz, here called Artysh river, and north of a low ridge which separates the Artysh valley from the plains. The southern boundary runs along this ridge for about 10 miles west of Altyn-Artysh, and from there almost due north to the crest of the Koktan range; then along this range eastwards of the Belauti pass, and from thence in a south-western direction to the village of Kushtignak, some 15 miles north of Faizabád. From here the southern boundary runs close to the right bank of the Káshghar river, until almost opposite to where the Artysh river runs into the plains.

During the first four days we all marched in company up the valley of the Bogoz river to the fort Tongitár, about 23 miles to the north by west; then to a Kirghiz camp, Bashsogon, in a north-easterly direction; Tughamati almost eastern, and Ayok-sogon in a south-eastern direction; the directions being from the last camps respectively.

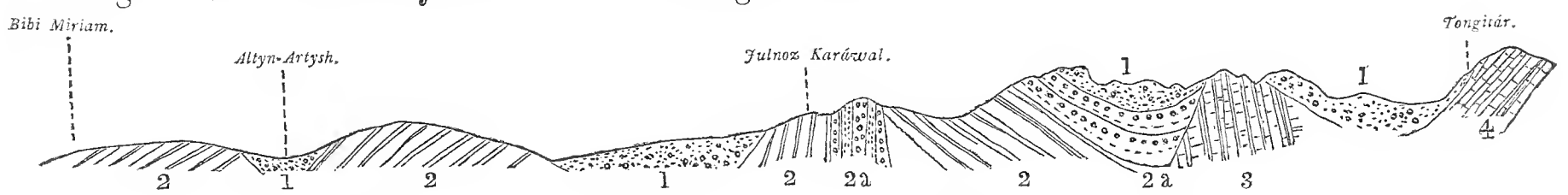
At Ayok-sogon Captain Trotter and I separated from the rest of the party, and marched northwards along the Ushturfan road to Jaitapa, and from thence across the Jigda Jilga in a north-east by east (?) direction to the camp at Uibulák, crossing the Uibulák pass, passing a second jilga, and turning then for almost 9 miles more northwards to the Belauti pass, beyond which lies the valley of the Kakshal or Aksai river. On our return we passed Ayok-sogon, Karáwal, about a mile from our former camp of the same name, and visited Kulti-ailak and Faizabád, returning to Yangishahr on the 3rd of March.

It was not a very favourable time for travelling in these regions, not so much on account of the cold, as in consequence of the heavy falls of snow which appear to occur over the whole of the Thian Shan during the second half of February and first half of March. During the last few days of February we were almost constantly wading in fresh-fallen snow, though on the saline plains it melted very rapidly. The snow naturally interfered seriously with our observations.

[1] Yilak, or Ailak, is the summer, Kishlak the winter, residence. Amongst the pastoral wandering tribes of Central Asia, it is the practice to drive all the animals to higher elevations for pasture in summer, and to bring them to lower ground when the upland pastures are covered with snow. The terms mentioned are used by the Túrk tribes.

From a geological point of view the trip proved in many respects to be of considerable interest, particularly as supplementing some former observations made more to the west. Although there is not much variety in the rock formations, we may distinguish three successive series.

1. The most southern part of the province, along the foot of the hills, is formed of alluvial gravels and sand, in whose unfathomable depths are swallowed both the Artysh and Sogon rivers before they can reach the Káshghar Daria.



Section from the Káshghar plain to Tongitár, about 25 miles.

2. The second series includes the low hills which extend diametrically from north to south over about 30 miles, while the prevalent strike is from north-east by east to south-west by west. All these lower hills are occupied by Artysh beds, of which I spoke in a former communication.[2] They are separated into two groups. The lower beds consist of greenish or reddish clays or sandstones, and the upper of coarse conglomerates, which on a hill south of Tongitár have a thickness of about 1,000 feet. At their contact both groups generally alternate in several layers. An anticlinal runs almost through the middle of their superficial extent. At the fort Ayok-sogon it is caused by a low ridge of old dolomitic limestones on which the Artysh clays and sandstones found a firm support. To the south of it the beds dip at angles of about 40° and 50° towards the Káshghar plain, in remarkably regular and successive layers. North of the ridge, which has no doubt a considerable subterranean extent in an east to west direction, all the beds dip towards north by west at a similar angle. Approaching the higher range, more recent diluvial gravels cover most of the slopes. The geological puzzle of finding strata of young beds as a rule dipping *towards* a higher range composed of comparatively much older rocks seems to me to be due, at least in this special case, to the phenomenon that the atmospheric waters which, descending on the crest, flow down the slopes of the high ridge, gradually soften them, and if a subterranean outlet facilitate it, the softened beds are worn away. While this process is going on, the more distant beds simply subside in order to fill the vacant spaces. In some cases a sinking or rising of the main range, or even an overturn of high and precipitous cliffs, seem to go hand in hand with the action of erosion, but it is not always the case. I hope to illustrate this idea by a few diagrams, partly derived from actual observations, on some future occasion.

3. A third series of entirely different rocks forms the main range of hills, which are a continuation of the Koktan range, and in which, more to the westward, are situated the Terek and Chakmák forts. The average height of the range above the plain of Káshghar is here between 1,200 and 1,300 feet, single peaks rising to about 1,500 feet. The whole of the southern portion consists, as far as I could see, of carboniferous rocks, in which, however, there is a great variety of structure. The lowest beds are very often a peculiar breccia-limestone passing

[1] In his field books Dr. Stoliczka speaks of these as probably triassic, but he may have changed his opinion subsequently, for in his published notes he classes them with the dolomitic limestone, and refers all to the carboniferous period.

[2] *Ante*, p. 24.

into regular limestone conglomerate. Above this are beds of solid grey dolomitic limestone, partly massive, partly stratified; the former possessing the character of reef limestone, and portions of it are indeed full of reef-building corals, crinoid stems, and a large *Spirifer*, the sections of which, when seen on the surface, have a striking resemblance to those of *Megalodon*.

North of Tongitár and about Básh-sogon I met in several places great numbers of fossils, but they were so firmly cemented in a calcareous matrix that only a few could be extracted. Among these I could recognise a small *Bellerophon*, *Productus semireticulatus*, and an *Athyris*. A new *Terebratula* was also very common. Here, about Básh-sogon and Tughamati, greenish shales occurred often interstratified with the limestones, beds of which were highly carbonaceous; the shales appeared to be unfossiliferous.

The limestone hills, which, as already stated, are a continuation of the Koktan range, extend in a north-easterly direction the whole way to south of the Belauti pass, where they are overlaid by a particularly well-bedded dark limestone very similar to that containing *Megalodon* north of Chung-terek. On this limestone rest greenish and purplish sandstones and shales which occupy the pass and the adjoining hills to the north-west of it; mineralogically these last rocks are quite identical with what we understand under the name of "*Bunter sandstein*," and it is by no means improbable that the Belauti beds are also of triassic age, as they succeed in regular layers those of the carboniferous formation.

A peculiar feature in this part of the hills consists in the occurrence of extensive plains to which the name *jilga* is generally applied. It means originally, I think, merely a water-course, and, on a large scale, these plains may be looked upon as water-courses of former water-sheets. They occur at the base of the high range, and in some respects resemble the *dúns* of the southern slopes of the Himalayas. North of Tongitár one of these large plains occurs within the limestone rocks, being surrounded by them on all sides. It must be about 30 miles long from east to west, and about 16 from north to south. Several isolated limestone hills and ridges occur in it, and it is drained off by the Bogoz and Sogon rivers, the former rising in the south-west, the latter in the south-east corner. The average elevation is about 5,000 feet. The greater portion is covered with a low scrubby vegetation, and, near the rivers, with high grass. The principal camping grounds are Básh-sogon and Tughamati. The whole plain, which affords good pasturage ground, is occupied by about 120 tents of Kirghiz during the summer.

The next jilga is the Jigda Jilga. It differs considerably both in its physical situation and in its general character from the former. It stretches from west by south to east by north for about 35 miles, while the diameter of the eastern half is about 20 and that of the western about 12 miles. Save for a few low hillocks it is almost a level plain throughout. On the north-western, northern, and north-eastern side it is bounded by the Koktan range, from which several water-courses lead into it, one about the middle from the north, and one from north-east of considerable size, this containing a large quantity of crystalline pebbles; the rock from which they are derived must be *in situ* near the axis of the ridge. A third big stream comes from the east, leading from the Uibulák pass. None of these streams had any water in them. On the south, east, and south-east the plain is bounded by the much lower hills composed of Artysh beds; their slopes covered with gravel.

An elevated gap or saddle situated in the south-west corner appears to connect this jilga with that of Tughamati. There is no drainage from this jilga; all the water is absorbed by the enormous thickness of sand and mud which fills the entire basin.

The southern part of the jilga, particularly south-east of Jaitupa, is lowest, and here a large quantity of pure salt, in small cubical crystals, is collected. The fact that there is such a large quantity of saline matter together with salt swamps in the southern part, seems to prove that this jilga at least, and probably most of the others, had been washed out by the sea, and that, while others had gradually, though only partially, drained off the saline matter, this one retained it, because it has at present no outlet. It is in fact a dried-up saline lake, which at some remote time was cut off from the sea, of which it was a fiord.

A third jilga is south of the Belauti pass and north-east of the Uibulák pass. It is about 8 miles in breadth and the same in length. There are two large water-courses leading to it from the range. On the southern side it is enclosed by Artysh and gravel beds but whether an outlet exists is not known. A southerly outlet very likely exists.

[Some little information as to the geology of the Thian Shan may be gained from Russian travellers, although, so far as I am aware, no general description of the range has been hitherto attempted by them; nor, indeed, have the mountains been sufficiently explored to enable its geology to be thoroughly understood.

With the exception of publications in the Russian language, the only original papers in which the geology of the Thian Shan is treated, so far as I know, are those by Semenoff and Severtzoff,[1] Osten-Sacken's interesting journey across the mountains, from Vernoye to the neighbourhood of Káshghar,[2] affording very little geological information. A very good general résumé of the section across the Thian Shan is given by Professor Suess[3] in a work which has recently appeared on the "Origin of the Alps," in which the geology of various mountain chains is discussed. The following translation will probably serve to give a better idea of the constitution of these mountain ranges than any which I could compile from the same materials.

After describing Dr. Stoliczka's discoveries, Professor Suess says, referring to the Russian explorers,—

"From these works it appears that these mountains are solely composed of old rocks, stratified and unstratified. To granite, syenite, and diorite succeed old slates, and then palæozoic limestones, amongst which the existence of mountain limestone is proved by fossils. The newest formation is Permian (Rothiegende) in the form of red sandstone and conglomerate, locally containing salt and gypsum. A band of red porphyry runs along the northern foot of the most northerly of these chains, the Trans-Ili-Alatau.[4]

"No mesozoic or tertiary beds are known to occur; consequently the succession of strata is nearly the same as in the Kuenluen, and as, according to Richthofen, in a great portion of the Chinese empire. The mountains are composed of great folds, the strike of which occasionally corresponds with that of the separate chains.

"The main chain of the Thian Shan consists, according to Semenoff, of two parallel axes of granite and syenite, the southern of which forms the principal ridge of the mountains,[5] the northern the ridge of a

[1] Semenoff; Erforschungsreise im Innern Asiens im Jahre 1857, Pet. Mit., 1858, p 350: Narrative of an exploring expedition from Fort Vernoye to the western shore of Issik-kul Lake, Eastern Turkestan.—Jour. Roy. Geogl. Soc., 1869, p. 311.

Severtzoff: A journey to the western part of the celestial range (Thian Shan), Jour. Roy. Geogl. Soc., 1870, p. 343 (translated from the Russian).—Erforschung des Thian Schan Gebirgssystems, &c., Erganzungshefte No. 42, 43, Pet. Mit., 1875.

[2] Jour. Roy. Geogl. Soc., 1870, p. 250.

[3] Entshehung der Alpen, 1875, pp. 135, 142.

[4] The names adopted for these various mountain chains by Russian and German geographers are cumbrous, and might be simplified with advantage. The Trans-Ili-Alatau is the range just south of Fort Vernoye, and is the more northern of two parallel chains north of Lake Issik (Issik-kul).

[5] The main range is considered to be that lying south of Lake Issik. The highest and best marked portion of this main range lies further to the eastward than the meridian of the lake.

parallel secondary chain. Between the two the palæozoic rocks rise to a considerable elevation, forming synclinal and longitudinal valleys. We shall follow the section to the north-east, from the foot of the principal ridge, according to Severtzoff's latest accounts, and begin at the Naryn River, the valley of which is bounded on the south by an outer range of the Thian Shan, the Chakir-tau. This consists of granite and mica schist, the opposite slope of the valley being entirely composed of contorted clay-slate, which locally, overlaid by dark violet porphyry conglomerate, extends to the north-west to the top of the Sari-tau, in which, at the pass of Barskoum, syenite is exposed.

"Proceeding from this pass towards Lake Issik diorite and serpentine are first seen; then mountain limestone, which forms a synclinal. This synclinal coincides with the longitudinal valley separating the Sari-tau from the next range to the north, the Terskei-Alatau, and this latter corresponds to the Sari-tau ridge precisely, so that, on the north side of the intervening valley, first mountain limestone with the slope reversed, then diorite, and finally syenite, are met with. Below, on the shores of Issik-kul, sandstone is found, which may be compared with the carboniferous strata of the Kara-tau.[1] At the eastern end of Issik-kul the little range of Kisil-kija[2] consists of red argillaceous sandstone; this range lies nearly in the direction of the greatest (longitudinal) diameter of the lake itself, and in the line of strike of the Rothliegende at the western end of the lake, in the gorge of the Boam stream and on the northern slopes of the Khighiz Alatau.[3] Proceeding over the Santash pass into the region of the Trans-Ili-Alatau, this is found to consist of granite intersected by two or more bands of limestone standing at high angles or bent into trough-shaped curves; one of these bands forming the ridge between the rivers Chilik and Chanishk.

"Finally, the granite northern slopes of the Trans-Ili-Alatau, as already stated, are terminated, towards the north, by a long but rather low chain of hills which consist of porphyry."]

[1] North of Chemkend and Tashkend. | [2] Tasma mountains on some maps.

[3] Now called on many maps Alexandrovski range.

PART VI.

From Yangihissár, Káshghar, to Panjah, in Wakhán, by the Little Pámir, and return journey by the Great Pámir.

[This section, like that describing the country between Mari and Leh, is simply compiled from Dr. Stoliczka's diary. It commences from Yangihissár, two marches, or about 40 miles, from Káshghar, on the road to Yárkand. Thence the route followed led in a south-west direction through the district of Sarikol (Sirikol) to the frontier of Wakhán, at or near Aktásh, a distance of about 150 miles in a direct line, and thence in a west-south-west direction for 120 miles more across the Pámir steppe to Panjah or Kila Panjah in Wakhán. The road from the Yárkand frontier to Panjah traverses a district known as the Little Pámir, and follows the more southern of the two streams which unite near Panjah to form the head of the Amu or Oxus; the return route to Aktásh was by the northern stream (that followed by Wood) and the Victoria lake. From Aktásh the party with which Dr. Stoliczka was associated returned by the same route as before to Yangihissár. The geological notes made on this portion of the return eastward journey have been incorporated with those made in the same localities on the westward route. The former largely supplement the latter, which were made when the ground was much concealed by snow.]

March 21st, Yangihissár to Ighiz Yar.—Started for Sarikol under Gordon, with Biddulph and Trotter. March of about 18 miles almost due south. A mile from Yangihissár we crossed several low ridges, extending for about a couple of miles, of what appeared to be upper Artysh beds, consisting of sand, clay, and conglomeratic beds. The dip was at first north by east, then the beds were horizontal, and further on they dipped to south by west. Crossed the Yangihissár stream, and traversed, first, a saline plain, and then one of gravel. The ascent throughout was very gradual, but must have amounted altogether to more than 1,000 feet.

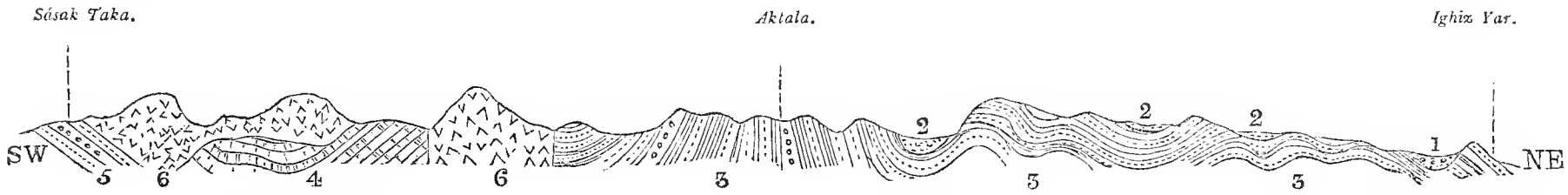
March 22nd, Aktala.—A march of about 18 miles, chiefly in a south-western direction. The low hills west of Ighiz Yar are composed of lower Artysh beds, hardened greenish sandstones much contorted.[1] Leaving Ighiz Yar, we crossed the plain for about 3 miles, and then entered the narrow valley of the Rin or Ring river.

The rocks at the entrance are lower Artysh sandstones, much contorted and disturbed. They continue for fully a mile, and are then succeeded by greenish sandstones and shales of a much older appearance. These rocks are again at first very much disturbed, but further on they dip regularly at a low angle to west by south, or even to west. The general dip, however, appears to be north-east. Nearer to the camp Aktala, the sandstones and slates alternate with highly carbonaceous shales and slates, and some highly ferruginous or hæma-

[1] On the return route from the Pámir and Wakhán on this march from Aktala to Ighiz Yar the following remark occurs: "The same slates and thin-bedded sandstones continue all the way. Towards the plain they alternate with coarser and conglomeratic beds; but they all appear to belong to the same old series." I infer from this that Dr. Stoliczka was finally inclined to believe that the rocks near Ighiz Yar, which he at first assigned to the Artysh beds (tertiary), were really older.

titic beds. These older beds very much resemble those we saw about Chakmák,[1] which also may turn out to be the same we saw north of Tám.[2] The sides of the hills are more or less thickly covered with *loess* dust, which much obscured the bedding of the rocks. I found no fossils.

Among the river boulders I noticed boulders of the red sandstone we saw south of Sanju, and a greenish syenitic rock.



1. Clay, 100 feet above the plain.
2. Gravel and loess.
3. Slates and sandstones, occasionally conglomeratic.
4. Earthy limestone.
5. Sandstone and conglomerate.
6. Greenstone.

Section from Sásak Taka to Ighiz Yar.

March 23rd, Sásak Taka, 13½ *miles*.—The dark slates, shales, and sandstone continued for a couple of miles, then followed greenish chloritic and felspathic rocks, very much like those south of Sanju, but more massive, being in fact a form of greenstone. These cap the whole series, and in one or two places come down to the bed of the river. Next follow earthy limestones, whitish or dark in colour, without any fossils, and then shales, carbonaceous slates, &c., with occasional conglomeratic beds and coarse sandstones. The whole of this series appears to be the same we saw on the road from Tám to Sanju. Some of the strata very highly carbonaceous, but not a trace of a fossil anywhere.

March 24th, Kaskasu.—Fourteen miles up the river Kaskasu. Nothing but the same carbonaceous slates and shales which are probably palæozoic, or occasional beds of grey more or less coarse sandstone, or even conglomerate. Not a trace of a fossil anywhere. The beds are mostly much disturbed and contorted, but where traces of regularity occur, they are seen dipping to south-west at an angle of about 50°. About half-way the old rocks were overlain by an old alluvial deposit, mostly consisting of boulders of the red sandstone, somewhat sparingly intermixed with boulders of gneiss. I have, however, not seen anywhere *in situ* the red sandstone; the greater portion seems to have come from a valley leading into the Kaskasu from the west about 4 miles east of our camp at Kaskasu. In several of the streams coming from the north, pebbles of white dolomitic limestone are seen containing a fossil like *Bellerophon*. These are probably from the white limestone, which is seen further on from the pass, and which is probably carboniferous. There were also blocks of a black earthy limestone, full of crinoid stems; this last is probably Silurian and interbedded with the black slates. A very similar limestone was seen on the road, but it contained no crinoids.

March 25th, Chehil Gombáz.—A short march of 11 miles across the Kaskasu pass. The bed of the Kaskasu river was strewn with boulders of gneiss, which must have come from the head of the stream. East of the pass the rocks are the same as before; palæozoic slates, sandstones, and conglomerates striking north and south, nearly vertical, much contorted, but sometimes dipping to the westward. On the pass the beds apparently dip north-east, but the strike is very indistinct, the surface being covered with fine clay, partly derived from the

[1] North-north-west of Káshghar, p. 26. | [2] Near the Sanju pass, south of Yárkand, p. 21.

decomposition of the slates, but principally, in all probability, a subaërial deposit, like the loess. In some places this clay covering is thin, and on a sharp incline parts of it are often carried away, so that some of the slopes have a rather rugged appearance. Looking north from the pass, I saw what was evidently limestone on one of the hills; it was probably the same as the carboniferous limestone seen south-west of Sanju, but there was no possibility of getting near the hill. In a north by east direction I saw red thin-bedded sandstones capping one or two hills, the beds apparently dipping to north-east. This red rock was very probably identical with the cretaceous red sandstone north-west of Sanju, thus remarkably indicating that this portion of the hills is a continuation of the Kuenluen.

From the pass to Chehil Gombáz the rocks are palæozoic carbonaceous slates, very variable in strike and dip. Near the pass the strike is indistinct: in the valley north of Chehil Gombáz, it is nearly east and west, the beds being vertical and much contorted.

March 26th, Pasrobát (across the Torat pass).—The whole way nothing but the same carbonaceous slates and shales, and partly sandstone, were seen. They were dipping at a very high angle to north by east or north-east by east. In some places they were interbedded with crystalline limestone, and with white quartzite, in strata of about 40 to 50 feet in thickness. At the junction of the two streams, the Pasrobát and the Tongitár, and much higher up, I noticed old diluvial gravel, in some places up to the thickness of 300 feet, the boulders mostly consisting of crystalline gneissic rock: some of the boulders are of huge dimensions, and all are well-rounded. These boulder deposits must have been formed by enormous rivers and large quantities of snow. The gneiss is either fine-grained, with biotite mica, sometimes almost schistose, or it is porphyritic with rosy quartz, white felspar and a greenish mica. There is little schorl to be observed in any of the pieces.

March 27th, Tárbáshi, about eight miles in a western direction.—The carbonaceous slates and sandstone continued for about a mile from camp, seeming, however, more micaceous. Then they gradually changed into dark carbonaceous mica schists with garnets; this again gradually into light-coloured mica schist, with more white quartz and less garnets, and this after about two and a half miles from camp into gneiss. All the strata were dipping at about 50° to north-east and north-east by east. In many places gravels conceal the rocks to a height of 150 feet above the river. On the greater heights dark-coloured schistose rocks are seen; they are mostly hornblendic.

March 28th, Balghun.—A march of about 20 miles across the Chichiklik plain and the Kokmainák pass. All the rocks around are gneiss, which gets gradually schistose, but it is cleaved in all directions and breaks up easily; the irregular cleavage entirely obliterates the bedding.

March 29th and 30th, Balghun to Chushman, and thence to Tashkúrgán (Sarikol).—Two marches of rather more than 20 miles altogether. The rocks are all metamorphic schists, rarely micaceous, but chiefly chloritic, quartzose, and hornblendic. North-west of the camp the dip is west by north; previously it was east by south. On the western side of the valley are thick gravel deposits, the boulders mostly of gneiss and syenite.

April 2nd, Kanshubar, 16 miles.—The whole way nothing but gneiss, in different variations, was to be observed. At first where we entered the Tongitár (valley), the fine-grained pale-whitish gneiss was interstratified with dark gneiss and syenitic gneiss, full of schorl; further on, syenitic gneiss prevailed, then bands of beautiful reddish gneiss occurred in it, with reddish-brown quartz, reddish glassy felspar in large crystals, and bits of schorl. Further on, the gneiss became more ordinary, both coarse and fine grained.

April 3rd, Kogachak, near Aktásh.—[Frontier of Sarikol belonging to Káshghar, and Wakhán under the rule of Kabul.] Followed up the valley for about a mile, when the gneiss was apparently underlain by black palæozoic slates, strike almost from east to west, and the dip very little towards the gneiss—or, rather, the beds were vertical. I could not find a trace of fossils. The slate is brittle, and very much cleaved in different directions : it would not do for roofing purposes, unless large quarries were opened. The slates continued for more than a mile, then they gradually became calcareous, and a series of thin-bedded whitish limestones followed—first, again, almost vertical, but, a little further on, distinctly dipping at an angle of about 50° towards the slates, though evidently younger. The limestone was dolomitic and highly bituminous, but unfossiliferous. After about a mile it changed to grey limestone, and became slaty. Then followed a band of greenstone for about half a mile, overlain by brownish-black shales, apparently carboniferous ; and these shales were overlain by greenish dolomitic crinoidal limestones, lithologically the same as those which I found to be carboniferous in the Artysh district. I dare say this limestone is also carboniferous. However, the upper beds of this limestone series are paler, and apparently less dolomitic ; and in them I found a cordiform pelecypod, like *Megalodon*, very common. Possibly the whole of the limestones, but certainly those on the western side of the range, are triassic. They rest here on purple and greenish shales and slates, which are afterwards traversed by greenstone. (See also diary of May 6th.)

April 4th, Onkul.—A march of about 24 miles. Crossed a spur over an old gravel deposit, and traversed a valley, the rocks on both sides of which were whitish triassic limestone, resting on reddish shaly rock, which, again, overlaid black slates, evidently palæozoic. Before we reached camp the slates rested on gneiss.

April 5th, Oi-kul or Kul-i-Pámir Khurd (*Little Pámir Lake*).—Marched about 24 miles along the valley of Pámir Khurd, or Little Pámir. The rocks composing the hills to the left of the valley are all gneiss to an elevation of 2,000 or 2,500 feet above the valley; those to the right are higher and more sharply ridged, but their composition could not be ascertained.

April 6th, Langar.—Marched about 24 miles. After 6 miles, in a west by south direction, the hills to the north became black slates, resting on gneiss. These same slates were seen dipping at an angle of about 60° to north-east by north at the entrance into the valley, which was here very narrow. They were overlain higher up by reddish slates and conglomerates, and the whole of the series has bands of quartzite, often intercalated : one of these quartzite bands seems to have passed right across the stratification of the slaty rocks at the entrance of the narrow part of the valley from the Pámir, which here terminates. The gneiss on the Pámir appears to have had only a very slight dip to north. The black slaty rock continued all the way to camp.

April 7th, Daraz-diwán, 15 miles.—Black slates, dipping north by east, were seen on both sides of the valley, and on the right the purplish or reddish slates and conglomerates rested on them. The conglomerates consisted of angular boulders of white quartzite in a reddish or purplish matrix. I saw fragments of similar conglomerate in the Sanju river.

April 8th, Sarhada.—March of 11 miles. For the first 2 miles black slates were seen along the road, which was above the level of the river; further on, the slates rested on the same fine-grained gneiss which we had seen at Pámir Khurd, until within half a mile of Sarhada, where the slate again came down into the valley.

Throughout the valley, from the spot where it was entered from Pámir Khurd, old banks of bedded clay and gravel are seen up to 1,200 and 1,500 feet above the present level of the

river. They are generally seen at the turns of the river, and can be traced all the way down, but are nowhere more extensive. Before the river cut its present deep bed, its course was probably often interrupted, and small lakes formed, or, at least, its course was retarded, so as to form these deposits.

April 9th, 10th, and 11th, Sarhada to Patir, halting at Patuch and Yúr.—Three marches of $4\frac{1}{2}$, 15, and 12 miles. Black slates alone were seen till 9 miles beyond Patuch, thence gneiss (fine-grained) and metamorphic rocks for the remainder of the way. The gneiss is sandy, and disintegrates easily.

April 12th and 13th, Patir to Panjah, or Kila Panj, halting at Zang; 20 miles from the former, only 3 from the latter.

[No special description of the geology is given. The beds seen were probably all metamorphic, the same as before. A hot spring opposite Patir is said to rise in black metamorphic slates.]

All the hills at Panjah consist of a metamorphic quartzose schist, which composes the hills on the left bank of the valley. The rocks dip to south or south by east into the valley: a few miles west they are overlain by dark hornblendic schist.

[After a halt of 12 days in Panjah, the party marched back to Káshghar territory by the Great Pámir, re-entering their former line of march at Kanshubar, east of Aktásh.]

April 26th and 27th, Panjah to Langerkish, 6 miles only.—Visited the hot spring near Zang: the water is 120°. The rocks are quartz, hornblendic, and mica schist, with garnets, dipping to the south-east.

April 27th, Yumkhana, 16 miles.—Old clay deposits reach to about 2,000 feet above the present level of the river. The metamorphic schists are very variable, but highly micaceous throughout (containing biotite); they still dip to the south-east, and include beds of white marble. On the left bank of the river they seem to dip under the gneiss, which is not distinctly stratified.

April 28th, Yolmazár, 12 miles.—Rocks same as before—all fine-grained gneiss, with biotite,—very much resembling the Himalayan central gneiss, with biotite mica, traversed mostly by thin veins of albite granite, with muscovite. It really seems that this is the continuation of the central gneiss, in which the Spiti and Záskar secondary rocks may form a bay, extending from south-east towards north-west. About Drás the secondary rocks go over a saddle into Kashmir, but the gneiss continues northward. Hornblendic beds often occur in the gneiss; they consist of dark, rather homogeneous rocks, which include hornblende and staurolite crystals.

April 29th to May 1st, Yolmazár to Lake Victoria (Wood's Lake).—Three marches, altogether about 37 miles.

[Rocks throughout described as gneiss; that on the first march described as containing a little green mica or chlorite; on the second but little rock was seen in place, the valley being largely occupied by beds of pebbles and boulders, which form terraces along the sides, whilst the hills were covered with snow. The gneiss seen was "remarkably altered, craggy, conglomeratic, split in all directions, and as if it had been burnt," but no trace of an eruptive rock was seen.]

The shingle boulders were mostly rounded; some of very large size only slightly so, and mixed with sand. The whole mass must have been accumulated more by the agency of snow and ice than running water.

[The hills around the lake are described as entirely of gneiss, and rather sharply pointed.] The lake is about two miles in width, and surrounded by terraces of rounded worn boulders, mixed with sand. These terraces rise to at least 100 feet above the lake, and show that the lake was formerly much more extensive than it now is. [The details will be found in the diary.]

May 2nd, Shashtupa, 18 miles.—For the first 6 or 7 miles the rocks are apparently gneiss; further, black slates and shales overlie the metamorphic rocks, and the hills on both sides become more rounded. Immediately above the gneiss the slates look rather metamorphic, but, further on, they are of the usual type, and reddish beds overlie them near the camp. The dip is low to north by east.

[The whole march nearly was over what Dr. Stoliczka terms "shingle beds," and the watershed was formed by a mixture of boulders and sand. See diary.[1]]

May 3rd, Isligh, 18 miles.—About three miles north of camp the upper reddish slates of the silicious group are overlaid by darkish grey limestone, dipping to north by east. I found no fossils in it. This limestone (α) is about 1,000 feet thick, and extends for about a quarter of a mile. Then follows a very indistinctly stratified white or light grey limestone (β), which must be at least 2,000 feet thick, and extends for about one mile. I saw *Crinoid* stems in it, but nothing else. After this follows, again, a darker grey limestone, evidently belonging to a different series, being unconformable on the former. This series of limestones forms the highest ridge, some of the rugged mountains rising to fully 20,000 feet; and the thickness of the rocks must be from 3,000 to 4,000 feet. The general strike is west by north to east by south, and the dip to north by east, or almost north, with angles ranging from 80° to 90°. The thickness of this limestone series must be about 3,000 feet. The whole of these limestones appear to be of palæozoic age—probably for the most part carboniferous.

After this follows a great series of dark shales, with beds of limestone. The shales themselves (δ) are highly carbonaceous, and the limestones are earthy, mostly thin-bedded, but greatly contorted, rising in more or less vertical ridges.

May 4th, Aktásh, 36 miles.—After four miles over the plain, the road led for two miles through a narrow gorge between limestone (ε), on which, further on, rest brownish, rather silicious sandstone, and grey, then black, crumbling shales. The road crosses a low pass, and then follows through these shales, in almost a due eastern direction, to the junction with the Isligh. The whole road passes through these shales, with a little sandstone, but more of the earthy limestone. The series extended north, as far as I could see, the shale hills being rounded, and the limestone ridges sharp. Greenstone appears to pierce through it in the distance, and the elevations of the hills appears to decrease. South of the road runs the high limestone range in a west by north to east by south direction towards Aktásh. The shales (δ) and limestones (ε) appear to be triassic. Near Isligh I saw a lot of *Rhynchonellæ* in one of the earthy limestone beds, but could not extract any thing very recognisable.

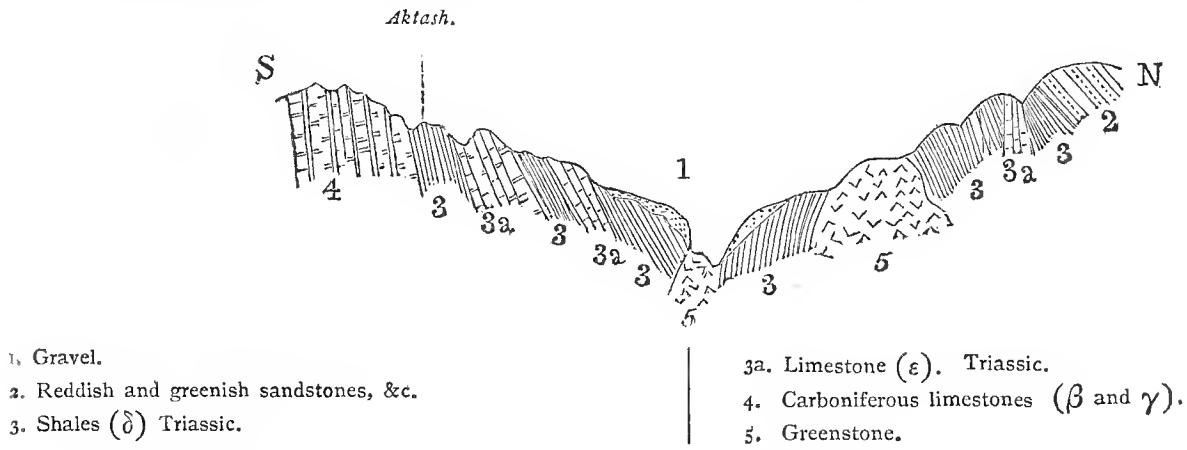
May 5th, halted at Aktásh.—Going about a mile north of camp, and then tunring in a western direction up a gorge, I found myself north of the great limestone hill, and here, resting on the limestone, were the dark crumbling shales, exactly like the Spiti shales in mineralogical character. The shales (δ) contained a few beds of the brown sandstone, but both appeared entirely unfossiliferous. In the interbedded limestone (ε) I found, however, a great number of *Rhynchonellæ*, which decidedly appear to be triassic, if not younger. In the more compact limestone I could only see crinoids, no other distinguishable fossil; not a trace of a *Cephalopod*. In a block of more earthy grey limestone loose in the stream bed I got several *Rhynchonellæ*; but I am not sure whether that limestone is (ε); it seems more probably (γ)

[1] It is not quite clear from the diary what Dr. Stoliczka's views were on the subject of these accumulation. He repeatedly says they must have been brought down by snow, or snow and ice. He never mentions glaciers or moraines, and never notices the presence or absence of striation on the rocks.

Afterwards I went south of the camp, where on our road westward[1] I got a section like that of a *Megalodon*. The limestone is mostly dolomitic, white or light grey, and less bituminous than (ε). I got crinoid stems in it, and a small *Pecten;* I could not say whether lower trias or carboniferous.

May 6th, Kanshubar (*same camp as on April 2nd*).—Two and a half miles from Aktásh, at a spot where the stream from the Nezatásh pass is joined by another flowing from the south-east, there is a mass of greenstone in the shales, and east of that mass the shales are very much altered, evidently indicating that the outburst of the greenstone must have taken place after the deposition of the triassic shales. Looking north, the shales continue for about a couple of miles, composing the hills, which rise to about 3,000 feet above the valley. To the north-west is a great mass of greenstone again, while a sharp ridge of limestone runs through the shales, coming from the west, and disappearing and broken up towards the east. Further on, the shales are seen to be overlain by reddish sandstones and shales, towards the top much alternating with greenish-grey beds; and this series is again capped by a light-brownish rock of inconsiderable thickness. These last rocks and the limestones dip north by east, but the crumbling shales are very much contorted, mostly by the greenstone.

The section from Aktásh to the north is something like this:—



Sketch section of the rocks north of Aktash.

Proceeding towards the Nezatásh pass, I found in the limestone (ε) dark beds full of *Halobia Lomelli?*, and I also noticed the *Rhynchonella* limestone, which is very earthy and brown, *in situ* in the shales. In the limestone (ε) *Rhynchonellæ* are very rare, or, at least, very difficult to observe. The limestone (ε) is, however, always very much less bituminous than (γ), and usually darker, and weathers out in flakes, which peel off the surface, while (γ) is usually massive. Limestone (ε) forms the Nezatásh pass in a ridge crossing the pass, but the passage itself is in shales, which are also seen in a kind of basin east of the pass, the basin being quite encircled by very high cliffs of limestone (ε). Crossing into the stream, which comes from the south, and combines with that flowing eastward from the pass, I observed a number of pelecypod sections in the limestone, which appear to belong to *Megalodon*. They were rather large, but otherwise not distinguishable.

Further on, the shales were several times crossed by greenstone, and then followed the bedded grey rock. The carboniferous limestone ridge runs from Aktásh almost due eastward, and about 5 miles before reaching Kanshubar it turns gradually to south-east, still retaining its great height.

[From Kanshubar the return route to Yárkand *viâ* Ighiz Yar was over ground previously traversed, and the geological notes have already been incorporated with those of the journey westward.]

[1] See notes for April 3rd, p. 38.

PART VII.

From Yárkand to Burtsi, south of the Karakoram Pass, *viá* Kugiár, the upper valley of the Yárkand River, Aktágh, and the Karakoram Pass.

[This route lies in general considerably to the west of that traversed by Dr. Stoliczka in the preceding autumn. For two marches from Yárkand to Karghalik the road is the same as before; thence it leads a little west of south across the Kuenluen to the upper valley of the Yárkand river; it turns eastward up the valley of that stream as far as Aktágh, where it meets the former route, but it then turns southward across the Karakoram pass. The following notes commence from Karghalik and are copied, like those in the preceding section, from the diary.]

May 31st, Karghalik to Beshterek, 20 miles.—The first 10 miles over gravelly desert; thence the road lies up the Kugiár stream, a broad desert valley, nearly a couple of miles wide. Gravel beds, as much as 150 feet thick in places, extend up to the village: they are evidently alluvial, and not Artysh beds, though the reddish sandstones at Bora[1] belong to the latter. Lœss rests on the gravel, and in places has been re-deposited by the river and stratified. There is a good deal of this stratified loess in the valley itself, but it is chiefly sand.

June 1st, Kugiár, 17 miles.—For 14 miles the road lay across desert, over somewhat elevated terrace land of sand and gravel. About 4 miles north of Kugiár, Artysh beds, clayey sandstone, and fine conglomerate are seen below horizontal beds of diluvial gravel. Further on, they again entirely disappear under the diluvial terraces, which rise about 200 feet above the elevated ground. The amount of sand, clay, and gravel brought from the hills is something enormous. The Artysh beds evidently form the axis of the low ridge, which runs from east to west, about 4 or 5 miles north of Kugiár; but they are covered with diluvial gravel.

June 2nd, Ak Masjid, about 27 miles.—The first half of the road is entirely over gravel beds, then a grey dolomite begins to crop out. The beds undulate, but the general dip is north: not a trace of a fossil could be detected. Further on, close to camp, a reddish, somewhat silicious sandstone, and thin-bedded streaked limestone of the same colour, with a high northerly dip, underlies the grey dolomite, and rests upon other grey and whitish dolomitic limestone, less distinctly stratified. As a rule, dust covers all the slopes of the hills so thickly that, except on a precipitous cliff, not a trace of solid rock can be seen. In the valley, loess attains a thickness of fully 30 feet; it is partly stratified, but the accumulation appears mostly due to moisture.

June 3rd, Chiklik, 13 miles.—Up to the foot of the pass the grey limestone rock continues, gradually becoming in places thinner bedded, streaked, and metamorphic. Near the foot of the pass it changes to a stratified chloritic rock, while the grey limestone occupies the

[1] These were noticed in Part III, and were observed on the road between Sanju and Yárkand; *ante*, p. 22.

greater height. The green rock alternates with thiek beds of a white quartzose and ealcareous sehist, and beyond the pass the green rock beeomes more solid, loses its stratifieation, and beeomes a regular greenstone, exactly like that I met with east of Sastekke, on the Sarikol road. Black slate I only saw in one or two plaees, and then in mere fragments or bloeks; but it is evident that the whole series of roeks is the same as that south-west of Sanju.

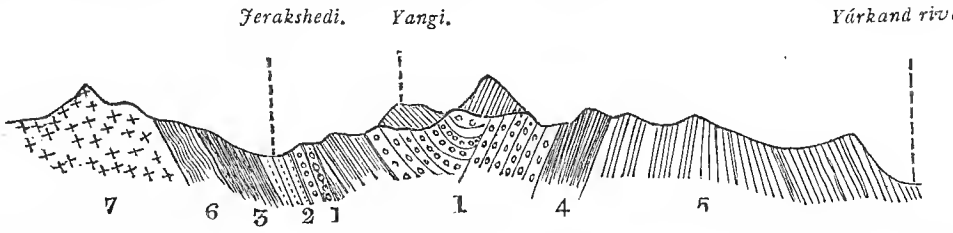
June 4th and 5th, Chiklik to camp, about 2 miles west of Mazarkhoja.—Two short marehes, together about 16 miles. Nearly all the way nothing was seen but greenstone, similar to that near Sasák Taka : towards the end of the seeond mareh this unstratified greenstone is overlain by ehloritie sehists and other bedded metamorphie rocks, resembling those to the north of the Sanju pass.

June 6th and 7th, Mazarkhoja to Grinjikalik.—Two marehes, together 18 or 19 miles. A mixture of metamorphie roeks was met with, like those north of the Sanju pass, dipping at a rather high angle to north-west, west, and south-west. The whole series seems much disturbed. The prevalent roek is a quartzitic and highly hornblendie schist, traversed in all direetions by ramifying veins of white quartz, with some sehorl, and by other darker veins, eontaining hornblende.

June 8th, Jiraksheldi, 10 miles.—The same metamorphie rocks eontinue for about a mile beyond yesterday's eamp, and rest here on light-eoloured, rather fine-grained gneiss, whieh is indistinctly stratified, and dips to the north-west. It is traversed by dark hornblendie veins. This greyish white gneiss eontinues for a eouple of miles, and rests on an unstratified mass of fine gneiss porphyry,[1] similar to that I saw west of Sarikol. This fedlspathie gneiss seems to form the axis of the whole metamorphic mass; for, further to south by east from this eamp, within about a mile, it is again overlain by the same somewhat fine-grained greyish-white gneiss, dipping to the south. This gneiss is, again, overlain at the camp by almost vertical and much-contorted beds of blaek shale, grey sandstone, and eonglomerate, the same as I saw north of Tám. The eoarse eonglomerate has a comparatively reeent aspeet, but the whole series of roeks must be upper palæozoie, although one eannot help doubting the faet.

June 9th, Kulunaldi, 12 miles.—[This mareh led aeross the main ridge of the Kuenluen by the Yangi pass (16,000 feet), and down again into the upper valley of the Yárkand river. The eorresponding pass to the eastward erossed on the journey to Yárkand is that of Suget.]

From yesterday's camp, the sandstones, eonglomerates, and interbedded shales continued up the pass, where the eonglomerates were of great thiekness, evidently oeeupying the top of the series, and dipping with a slight angle to west. On the other or western (southern) side of the pass, the eonglomerates and sandstones all eontinue for about $2\frac{1}{2}$ miles highly inelined, and dipping towards east by north; they rest at about the third mile from the pass on blaek slates, whieh soon pass into dark grey and greenish metamorphic schist, sometimes with small garnets.



1, Conglomerate; 2, Sandstone; 3, Shales; 4, Black slates; 5, Metamorphic rocks, dark-coloured, with quartzite; 6, Fine-grained gneiss,; 7, Unstratified granitoid) porphyritic gneiss.

Section across the Yangi Pass, north of Yárkand River.

The metamorphie series is often traversed by veins of a solid greenstone-like roek, and towards the Yárkand valley there is a considerable thiekness of a white quartzitic schist,

[1] Evidently, from the description, a granitoid rock.

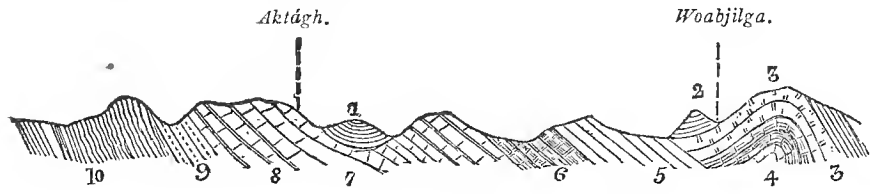
more or less massive: under it lies a brownish sub-metamorphic schist, which is also found on the other side of the Yárkand river at the camp.

June 10th, Kirghiz Jangal, 16 miles.—The sub-metamorphic schists near Kulunaldi are overlain by a reddish, very coarse conglomerate, and from beneath this, further along the road, a series of grey and pink metamorphic schists crops out, occasionally with graphitic layers interstratified. The last continue up to camp. The beds dip first to west 30° north, and afterwards almost west. The coarse, reddish conglomerates are the same which I saw in going from the Pámir-kul to the camp Langar, in Wakhán.

June 11th, Kashmir Jilga, about 24½ miles.—The rocks are all grey silky, or brownish mica schist. For the first 14 miles it is difficult to see any stratification, the schists having distinct bacillary cleavage; but further on, the schists dip to the north-east on the right bank, and for the last 6 or 7 miles the valley runs along an anticlinal, the beds dipping on the right bank to north by east, and on the left bank to south by west, at an angle of about 50°. The schists decompose easily, and cover the slopes with fine debris. Almost all along the bank of the river there are extensive deposits of detritus, some of them containing beds of clay and sand, left by the river. At the openings of the lateral ravines there are extensive fans of debris, some of them more than 100 feet thick.

June 12th, Kufelang, 11 miles.—Rocks the same all the way; greenish metamorphic schists, often alternating with graphitic layers. The schists decompose and break up very readily, and the hill-sides, in some cases up to the top, are covered with debris, loose or cemented together. The dip is very variable, usually at a high angle to south-west or south.

June 13th, Aktágh, about 20 miles.—[Here the road joins that followed on the journey northward, but it immediately diverges again.]



1, Argillaceous beds (? tertiary); 2, Shaly sub-metamorphic beds (trias); 3, Grey limestones (trias); 4, Red limestones, with *Ammonites batteni*, &c. (trias); 5, ? Trias; 6, Dark triassic limestone; 7, Limestone (? carboniferous); 8, Grey limestones (? carboniferous); 9, Red calcareous sandstone; 10, Sub-metamorphic schists.

Section near Aktágh.

The schists, greenish and metamorphic in general, but blackish and sub-metamorphic in parts, continue for about a couple of miles along the river; they are mostly almost vertical. Then some of the beds incline to the south, and are more regularly bedded; but there does not seem to be any distinct break between these latter and the vertical beds. After the second mile the greenish silky schists are overlain *unconformably* by reddish earthy and calcareous sandstones of about 150 feet in thickness, dipping regularly to south by east at an angle of about 30°. These reddish beds pass into distinctly bedded grey limestone and whitish marl of some 500 feet at least, the dip being to the south, but the angle gradually decreasing until the beds, after some 8 miles, become almost horizontal. Further on, they again dip to the southward, and the top beds have a reddish colour. There are greenstones in these rocks, like those which I saw about Aktásh on the Pámir; and the limestones must be carboniferous or triassic, but I could not find a trace of a fossil. The higher beds are often brownish and sandy; some beds almost a calcareous sandstone, alternating with conglomeratic beds.

Near Aktágh the series is overlain by much more recent looking earthy and conglomeratic beds, readily yielding to decomposition. The hill Aktágh at camp consists of these (? tertiary) beds, dipping at about 45° or 50° to the south.

There must be greenstones somewhere in this southern direction among the dark crumbling rock.

The light-coloured bedded limestone strikes over to Karatágh lake, and the hills to the west, east, and south-east appear to consist of it. I noticed, when I marched last year, that their steepness indicates in part limestone cliffs, and some of them at least were of a light colour.

This is also the pale limestone seen north of our camp, some miles north of Khush Maidan, and no doubt these limestones extend to the south of Aktásh. [That is to say, that this pale limestone, which is probably of carboniferous age, appears to stretch across from the high ground between the Mastágh and Kuenluen ranges to the eastern edge of the Pámir.]

June 14th, Woabjilga, 12 miles.—The hills all covered with detritus.

A little way south of Aktágh the grey limestones, which appear to be carboniferous, are overlain by dark crumbling dolomitic limestone and sub-metamorphic shales, in several places in contact with greenstone, which is again either typical, like that near Aktásh, or it is dark, and very homogeneous in texture, and at first strikingly resembles basalt. Further on, the grey dolomitic limestones again crop out from under the detritus of the valley; and near the camp the sub-metamorphic schists are overlain by more compact grey dolomitic limestone, which rises high upon a hill a little south by east of our camp. These grey dolomitic limestones regularly bend over at the top, and in the centre are exposed what may be called *Hallstädt* or *St. Cassian* beds—a red, somewhat earthy, marble, with *Arcestes? johannis austriæ*, *Ammonites batteni*, *Aulacoceras*, and Crinoids. I shall speak of this red marble as the *A. batteni* bed.

The *A. batteni* bed is seen exposed far towards the west, overlain by the grey limestone, and is mostly highly inclined towards the north. I must see more of the whole triassic series to-morrow.

June 15th, Karakoram-brángsa, 14 miles.—Starting from Woabjilga, the grey triassic limestones were met with, afterwards the red limestones succeeded them, and continued to camp, often interrupted by patches of greenstone, which is greatly developed at the camp north of the pass.

June 16th, Daulatbeg Uldi (crossing the Karakoram pass), *about 22 miles.*—Leaving camp, the greenstones are underlain by black crumbling shale, in mineralogical character like the Spiti shales, but very likely triassic, like that near Aktásh. Then follows an alternation of grey or whitish limestones and shales and the triassic red limestone; and on these rest blackish and grey marly shales, which are overlain by almost horizontal strata of brown limestone, very much like the lower Taglang limestone, and which contains fragments of *Belemnites*. These *liassic rocks* form the Karakoram range proper, and extend far eastward. The hills to the west are much higher, and do not allow a distant view.

After crossing the pass, the road skirts the base of the centre ridge in a south-east direction; and here the liassic limestones come down several times, and about four miles from the pass grey marly shale, or almost marly limestone, crops out from under the brown limestone: both are evidently liassic. On the right bank of the stream more massive limestones occur, dipping to north-east, but very indistinctly. I should think that these are triassic limestones. They very readily crumble to pieces, being highly dolomitic; and these often contain reddish beds interstratified.

June 17th, Burtsi, 24 miles.—First we crossed the Dipsang plain, with solitary low hills, probably still belonging to the Taglang series. Then we ascended towards the watershed.

The low worn-down hills to the west were thickly strewed with round pieces of whitish or reddish compact limestone, intermingled with boulders, large and small, of fine-grained syenitic gneiss. This rock must be *in situ* somewhere near the head of the watershed. Further on were many greenstone boulders coming down from the west, and this rock must also be found in that direction. At last we descended into a narrow gorge, the sides of which for fully a mile consisted of a limestone conglomerate, the boulders of white, grey, or black limestone being well rounded and worn and cemented together by a stiff bright red clay. Upon this followed dolomitic limestone, rather indifferently bedded, massive and white, and this was overlain by bluish shales and well-bedded limestone, extending from about 6 miles north of Burtsi to the camp. These limestones appear to be triassic: they are compact, with layers full of small gasteropods, amongst which I recognised a *Nerinea*. The so-called Karakoram stones, *i.e.*, corals, occur in dark shales below the limestones, which are capped by a yellowish-brown limestone, well bedded, but of unascertained age. The whole series dips south-west, at a moderate angle. [The last paragraph closes the diary, and is here repeated, as it is entirely geological.]

Concluding Summary.

As this collection of Dr. Stoliczka's geological notes on the countries traversed during his journey was introduced by a brief account of his previous geological work in the Himalayas and Western Tibet, it may most fitly be concluded by a general sketch of the additional information which he has obtained in the countries north of those explored in earlier years.

His explorations in his last journey extended over portions of Northern Ladák, of the Mastágh or Karakoram, Kuenluen, Pámir, and Karatágh ranges, the last being a part of the Thian Shan. He also examined the plains of Yárkand and Káshghar, and the upper valleys of the streams which form the source of the Oxus or Amu. The notes on Kashmir, and on the Indus valley west of Leh, although interesting and affording some addition to our previous knowledge of the geology, do not touch on fresh ground, or add more than details to what was known before. Each of the other areas demands a few notes separately.

The Ladák range, north of the Indus, proved, so far as it was examined, to consist entirely of metamorphic rocks, principally syenitic gneiss. The same formations extend to the northward to the western end of the Pankong lake, and, so far as is known, throughout the greater portion of the Changchenmo, Shayok, and Nubra valleys, passing in places into a greenish chloritic rock, more or less schistose. These metamorphic rocks are believed by Dr. Stoliczka to be of silurian age. In the northern portion of the valleys named beds of dark shales and sandstones are met with, probably belonging to the carboniferous series: they are unfossiliferous, but agree with rocks of that age in Spiti and elsewhere, and they are succeeded, in ascending order, by fossiliferous triassic limestones, red and grey in colour, with dark shales; whilst the crest of the Karakoram pass, and some of the smaller hills immediately south of it, are composed of liassic rocks, containing fragmentary *Belemnites*. At one spot alone near Kium, in the Changchenmo valley, sandstones and conglomerates of comparatively recent aspect were observed, which are perhaps tertiary, and may belong to the same eocene formation as the rocks in the Indus valley near Leh.[1]

The valley of the Upper Yárkand river between the Mastágh (Karakoram) and Kuenluen ranges consists of metamorphic and sub-metamorphic schists and slates, reddish calcareous sandstone, and grey limestones, all unfossiliferous. The schists and slates are considered by Dr. Stoliczka as probably silurian; the other rocks, carboniferous. Some triassic limestones are found on the northern slopes of the Karakoram pass; and at Aktágh some recent-looking argillaceous beds were noticed, perhaps tertiary.

Two sections across the Kuenluen were examined—one, on the Karakásh river, the Suget and Sanju passes; the other, further west by the Yangi Diwán. On the former route the greater portion of the range consists of syenitic gneiss, associated with various forms of schists, with some of which pale-green jade is associated. On the more western route the same metamorphic rocks are found, but the syenitic gneiss is less developed, and there is a great quantity of greenstone.

[1] Drew (Jummoo and Kashmir, p. 343) has noticed the occurrence of hippuritic limestone (cretaceous) resting unconformably on older encrinital limestone (? palæozoic) in the Lokzhung range, north of the Lingzi-thung plain and east by south of the Karakoram pass. In the same work there is an excellent account of the extraordinary high plateaus of northern Ladák, west of which appear to be of lacustrine origin.

North of the metamorphic axis of the Kuenluen range, the hills sloping down to the plain of Yárkand consist principally of various forms of schistose rock, slates, and limestone. In the latter, north of Sanju, carboniferous fossils were found in some places, but the rocks are, as a rule, destitute of organic remains. On the western route the only limestone seen was dolomitic and unfossiliferous. Towards the edge of the plain, formations of later date crop out; and near Sanju red sandstones, capped by grey calcareous sandstones and chloritic marls, are found, the latter containing cretaceous fossils; and upon these, again, rest gravels and clays of still later date. The cretaceous rocks were not observed further west.

The ranges lying west of the Yárkand plain, and intervening between it and the Pámir watershed, appear to be composed chiefly of the same rocks as the Kuenluen, south of Yárkand. Only one section was examined, and this was traversed twice. Near the plain the prevailing beds are carbonaceous slates, sandstones, and conglomerates, probably palæozoic, with which greenstone is associated. A few limestones were seen, and traces of the red cretaceous sandstones of Sanju: the latter, however, was not examined *in situ*. No fossiliferous beds were observed, but the slates, sandstones, and conglomerates are probably palæozoic, like the corresponding rocks in the Kuenluen. Further from the plain, in the district of Sarikol, the slates and their associated beds become metamorphosed, and pass into schist and gneiss, upon which, close to the frontier of Wakhán, near Aktásh, rest black slates, and limestones of apparently carboniferous age; and above these, again, other limestones with triassic fossils, and sandstones.

The Pámir itself between the Yárkand frontier at Aktásh and Panjah, the principal village of Wakhán, was twice crossed, the return route lying a little north of the other, and each following one of the two streams, which unite to form the head of the southern or main source of the Oxus. The geology throughout is of the very simplest description. The carboniferous and triassic limestones were only found for a very short distance west of the Yárkand frontier; and thence to Panjah the whole country consisted of black slates, occasionally capped by reddish slates and conglomerates, and resting upon gneiss, which forms the great mass of the plateau. The slates are, doubtless, palæozoic; but no evidence of their precise age was obtained. The gneiss is fine-grained; it contains biotite, and is, in places, traversed by veins of albite granite, and it altogether so much resembles the "central gneiss" of the Himalayas north of Simla, that it may be a continuation of the same rock. Immense accumulations of boulders and sand were observed on the Pámir, in all the river valleys and around the lakes.

The two journeys made to the mountains north of Káshghar, which are a continuation of the Thian Shan range, and unite it to the Pamir or Bolor, scarcely extended beyond the southern skirts of the range, the greater portion of which lies within the Russian territory. The first of these journeys extended nearly 100 miles in a direction north by west, from Káshghar to a lake called the Chadyr-kul; the second, to a distance of about 120 miles north-east to the Belauti pass. After passing the gravel slopes on the edge of the Káshghar plain, and some ridges of sand and clays, which appear to be of tertiary date, and which Dr. Stoliczka calls the Artysh beds, the first range met with to the westward consists of dark triassic limestones, resting on greenish shales, and the next range of old shales, slates, and sandstones, with crystalline limestone. More to the eastward all the fossiliferous rocks are of carboniferous age: they consist of grey dolomitic limestone, resting on a limestone breccia, passing into conglomerate, and locally interstratified with greenish shales. This series, probably, represents the old slates and their associates seen further to the west. On this eastern route the carboniferous limestones extend to the Belauti pass, where they are capped by darker limestones, on which

rest greenish and purplish sandstones and shales,—all which rocks are possibly triassic. North of the old palæozoic formations to the westward volcanic outbursts of very recent date are found, and the remains of old craters are conspicuous; and beyond these, again, are limestones and slates of undetermined age, the latter occasionally showing signs of metamorphism. Some of the limestones resemble the triassic rocks in character, but no fossils were detected in them. The presence of metamorphic rocks in the ranges north of Káshghar is proved by the occurrence of gneiss pebbles in the gravels derived from the hills.

It is probable that coal occurs in places in the carboniferous formation, as specimens brought from the mountains were examined and roughly analysed by Dr. Stoliczka when in Káshghar.[1] Roeks of the carboniferous period are largely developed in Western Turkestan, and coal has been found in several places.

The plains of Yárkand and Káshghar consist of recent deposits of clay and sand, with occasional ridges of gravel and marly clay. They, doubtless, resemble closely the other great plains of Central Asia, all of which, having no exit, are basins of deposit, and are being gradually raised by the alluvium brought from the surrounding hills by rivers and streams, which dry up and lose themselves on the plains. Towards the edge of all such plains there are immense gravel accumulations,[2] which greatly conceal all the rocks. Below these gravels, all round the edge of the Káshghar plain, there is found a series of clays, sandstones, and conglomerates, often much disturbed, but evidently not of old date, called by Dr. Stoliczka Artysh beds, from the Artysh valley north of Káshghar, where they are extensively exposed. No fossils were found in them, but their discoverer was inclined to consider them marine. They present a marked resemblance, both in composition and in their position at the base of higher ranges, to the Sub-Himalayan rocks of Northern India, and the *molasse* of the Alps.

All of these deposits, and the rocks on the slopes of the hills for some distance from the great plain, are much concealed by an extremely fine unstratified accumulation, precisely similar in character to the *loess* of the Rhine and Danube, and which is evidently composed of fine dust, deposited by the atmosphere. The air in Eastern Turkestan, as in parts of China, is constantly, during the day, thick from the fine sand raised by the wind; so much so, that objects at a comparatively short distance are rendered invisible.

It is evident that there is great similarity in the geology of all the mountains surrounding the Yárkand basin. So far as they were examined, the prevalent formations were palæozoic, resting upon gneiss and other metamorphic roeks; and carboniferous limestones were constantly found largely developed. The only lower mesozoic rocks recognised were of triassic age, but traces of cretaceous beds were found to the south and west, whilst in the mountains north of Káshghar evidence of comparatively recent volcanic eruptions was met with. No representatives of the jurassic formations of the Himalayas and Western Tibet have hitherto been recognised in this part of Central Asia north of the Karakoram.

[1] Diary for 1st to 13th February. See also Severtzoff: Journal, Royal Geological Society, 1870, Vol. XL, pp. 410, &c. I am also indebted to Mr. Hume for a copy of a report by a Russian Engineer officer named Ramanoffsky, in which the occurrence of coal in Western Turkestan is described.

[2] I have described similar deposits in Persia: Quarterly Journal, Geological Society, 1873, Vol. XXIX, p. 493.